

GEOGRAPHIC SIGNIFICANCE OF DELIVERY ZONES IN AN E-  
COMMERCE ENABLED GROCERY DELIVERY STRATEGY

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL  
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2006

## ACKNOWLEDGEMENTS

The completion of this dissertation would not have been possible if it were not for the loving devotion of my wife, Tsuneko Herrel (also known as “Jaato”) and the enduring love and support of my mother Jean Herrel, who passed away before she could see me graduate with my Ph.D. I know, however, that she will see me graduate as she looks down from heaven. My three darling children, Schawn (also known as “Chub”), Lina Lee (also known as “Screaming Meemie” or “Angel Princess”), and Aaren (also known as “BoupToYouBoy”), have given me the will, perseverance, fortitude, and just plain heartwarming desire to achieve in life, both academically and professionally.

## TABLE OF CONTENTS

|                                                                                             | <u>Page</u> |
|---------------------------------------------------------------------------------------------|-------------|
| ACKNOWLEDGMENTS.....                                                                        | ii          |
| LIST OF FIGURES.....                                                                        | v           |
| ABSTRACT.....                                                                               | viii        |
| CONCEPTS AND METHODOLOGY.....                                                               | 1           |
| Purpose.....                                                                                | 1           |
| Concepts.....                                                                               | 3           |
| Methodology.....                                                                            | 4           |
| LITERATURE REVIEW.....                                                                      | 8           |
| Online Grocers' Failures, Difficulties, and Possible Solutions.....                         | 9           |
| Spatial Decision Support Systems.....                                                       | 18          |
| Online Retailer Geographic Issues.....                                                      | 25          |
| Grocer Web Site Design Issues.....                                                          | 29          |
| Artificial Intelligence.....                                                                | 30          |
| Online Grocers' Store Locations.....                                                        | 45          |
| Geographic Information Systems for Traffic Flow Simulation.....                             | 48          |
| Geographic Information Systems for Vehicle Routing and Logistics.....                       | 51          |
| Networks.....                                                                               | 56          |
| Data Visualization and Data Representation.....                                             | 59          |
| Geographic Data and Surface Representation.....                                             | 66          |
| Geographic Information Systems in Business.....                                             | 86          |
| Enabling Geographic Information Systems Technologies.....                                   | 92          |
| Spatiotemporality.....                                                                      | 101         |
| Other Supporting Literature.....                                                            | 107         |
| SIMULATION ELUCIDATION.....                                                                 | 122         |
| THREE SIMULATION SEQUENCES THAT RESULTED IN EXCEPTIONAL,<br>AVERAGE, AND MEDIUM PROFIT..... | 178         |
| Exceptional Profit.....                                                                     | 178         |
| Low Profit.....                                                                             | 179         |
| Medium Profit.....                                                                          | 179         |
| CONCLUSION.....                                                                             | 186         |
| SOURCES CITED.....                                                                          | 199         |

|                          |     |
|--------------------------|-----|
| BIOGRAPHICAL SKETCH..... | 215 |
|--------------------------|-----|

## LIST OF FIGURES

### Figure

|    |                                                          |     |
|----|----------------------------------------------------------|-----|
| 1  | Hexagonal layout.....                                    | 7   |
| 2  | Duration of delivery in days.....                        | 146 |
| 3  | Profit options settings.....                             | 146 |
| 4  | Minimum dollar delivery.....                             | 147 |
| 5  | Mandatory profit.....                                    | 147 |
| 6  | Delivery charge per concentric region.....               | 148 |
| 7  | Delivery charge per region interface.....                | 148 |
| 8  | Delivery charge per region pop up form.....              | 149 |
| 9  | Simulation options form.....                             | 149 |
| 10 | Number of orders error catching.....                     | 150 |
| 11 | Number of deliveries drop-down list.....                 | 150 |
| 12 | Duration of deliveries error catching .....              | 151 |
| 13 | Duration of deliveries drop-down list.....               | 151 |
| 14 | Region and legend color coordination.....                | 152 |
| 15 | Report dashboard for the simulation run on April 13..... | 152 |
| 16 | Simulation main map result with profit settings.....     | 153 |
| 17 | Pause function.....                                      | 153 |
| 18 | Profit options form.....                                 | 154 |
| 19 | Allow dispatch alerts radio button.....                  | 154 |

## Figure

|    |                                                                          |     |
|----|--------------------------------------------------------------------------|-----|
| 20 | Truck dispatch notification.....                                         | 155 |
| 21 | Simulation main map result showing truck usage.....                      | 155 |
| 22 | Report dashboard for the simulation run on April 15.....                 | 156 |
| 23 | Population report .....                                                  | 156 |
| 24 | Profitability chart.....                                                 | 157 |
| 25 | Total mandatory profit per simulation report.....                        | 158 |
| 26 | Residence report.....                                                    | 159 |
| 27 | Settings report.....                                                     | 160 |
| 28 | Delivery report.....                                                     | 161 |
| 29 | Simulation options form.....                                             | 161 |
| 30 | Simulation main map result showing three simulations.....                | 162 |
| 31 | Simulation charts report.....                                            | 163 |
| 32 | Simulation charts report showing second and third simulation.....        | 164 |
| 33 | Settings report showing three simulations.....                           | 165 |
| 34 | Total mandatory profit per simulation report showing three simulations.. | 165 |
| 35 | Residence report showing orders from the second and third simulations..  | 166 |
| 36 | Mandatory profit per concentric region on profit options form.....       | 166 |
| 37 | Mandatory profit per concentric region on settings report.....           | 167 |
| 38 | Submit Delivery Charge button.....                                       | 168 |
| 39 | Delivery charge per region interface.....                                | 168 |
| 40 | Delivery charge per region form.....                                     | 169 |
| 41 | Region A3 showing the delivery charge.....                               | 169 |

## Figure

|    |                                                                         |     |
|----|-------------------------------------------------------------------------|-----|
| 42 | Profitability chart showing profit for region A3.....                   | 170 |
| 43 | Mandatory profit per simulation report showing profit for region A3.... | 170 |
| 44 | Settings used with Intra-Regional Drive Time function.....              | 171 |
| 45 | Intra-regional drive time interface.....                                | 171 |
| 46 | Intra-regional drive time pop-up form.....                              | 172 |
| 47 | Settings report showing 15 minute intra-regional drive time.....        | 172 |
| 48 | Delivery report showing increased intra-regional drive times.....       | 173 |
| 49 | Inter-regional drive time interface.....                                | 173 |
| 50 | Settings report showing increased inter-regional drive time.....        | 174 |
| 51 | Delivery report showing increased inter-regional drive times.....       | 174 |
| 52 | Overall average population per region.....                              | 175 |
| 53 | Population per region interface.....                                    | 175 |
| 54 | Main map showing various amounts of orders placed.....                  | 176 |
| 55 | Regions showing higher and zero populations.....                        | 176 |
| 56 | Report dashboard showing various populations.....                       | 177 |
| 57 | Population report showing various populations.....                      | 177 |
| 58 | Profit and simulation options for high-profit scenario.....             | 180 |
| 59 | Profitability quotient and profit gauge for high-profit scenario.....   | 181 |
| 60 | Profit and simulation options for low-profit scenario.....              | 182 |
| 61 | Profitability quotient and profit gauge for low-profit scenario.....    | 183 |
| 62 | Profit and simulation options for medium-profit scenario.....           | 184 |
| 63 | Profitability quotient and profit gauge for medium-profit scenario..... | 185 |

Abstract of Dissertation Presented to the Graduate School  
of the University of Florida in Partial Fulfillment of the  
Requirements for the Degree of Doctor of Philosophy

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May 2006

Chair: Grant Ian Thrall  
Major Department: Geography

This work contains a geographic and logistic tool that will allow grocers who are contemplating to deliver groceries via e-commerce to better decide whether they should embark on that initiative. As web-based orders become more commonplace, this computer application will have the potential to assist both large and small grocers in the critical decision of starting a delivery service. The causes of failures of grocers are traced. An operational computer program is demonstrated, with embedded algorithms that make for a realistic simulation. The computer simulation together with the user-friendly interface “front end” provide a practical and also scholarly solution to a complex geographic problem.

## CONCEPTS AND METHODOLOGY

### **Purpose**

The potentially lucrative grocery home-delivery market largely remains untapped because of the financial risk and operational difficulty of running such a service. Also recent history is fraught with unsuccessful attempts at delivering groceries. The rapid bankruptcy of the high-profile Webvan company is possibly the worst debacle of all the grocery delivery attempts.

This dissertation contains a logistical simulation application to solve one of the most plaguing problems that some grocers have, which is the problem of deciding to initiate a home delivery service or not. The primary purpose of the simulation is to reduce the financial risk involved with rolling out an e-grocery initiative.

This means that grocers can take a quantum leap forward in satisfying the annual multi-billion dollar United States grocery market by using my application. This is also true for other industrialized countries. How is this possible? First, the great number of grocer home delivery failures is no secret. This could be resulting in many grocers hesitating to start a delivery initiative. Second, there could be a notable benefit to the people in much of the industrialized world if grocers can successfully deliver to time-strapped customers. Traffic jams and fuel consumption could decrease if people do not use their cars to shop after work. Third, a grocer can decrease the number of employees, such as cash register attendants and stock persons needed in the brick-and-mortar store because customers who would otherwise go to the store will not do so if the groceries are

home delivered. Fourth, the infirm and elderly will benefit because the competition to satisfy people who accept home deliveries could very well drive down delivery prices that otherwise would be out of the economic means of these people. This list of benefits is not exclusive, but should give justification to the claim that grocery home delivery is a benefit to not only the grocer who could make a greater profit or acquire more customers, but also to society in general.

No computer simulation application as presented here has ever been presented in a public forum, including academic journal articles or news media. Grocers who are contemplating deliveries will find this profit estimating simulation application easy to use, powerful in its functionality, and versatile to allow its use in the actual delivery operational operations. Actual customer addresses can be input into the application to generate simulated deliveries to loyal and prospective customers. Actual times that are required to deliver to each region can be input before the simulation begins. The output of the delivery data is shown is easy-to-read automatically generated reports. Round trip truck times that include the average time required to deliver within each region can be input separately into the application to give an accurate report of how long it takes a truck to leave the store, deliver to the households, and return to the store. Also, the number of trucks required to deliver to the population of all the regions can either be specified or calculated.

Because rarely is it possible to give a clear-cut yes or no answer about whether a business venture should be undertaken or not, the conditions where a online e-grocer (or a grocer who is taking orders by telephone) will reach a predetermined amount of profit can be determined by running this application. In other words, questions like, “by what

pathways can profitability be achieved?” and “what values do you need in combination to reach a predetermined profit?” must be answered before a grocer should begin delivering groceries.

Because profitability is naturally the goal of any grocer, this application gives an indication to the grocer about what clusters or sets of attributes that will work to achieve the required level of profit. Each simulation that is run can portray a different scenario of what is needed to achieve profitability.

### **Concepts**

In terms of this logistic application the term “Mandatory Profit” is used. The Mandatory Profit is the profit that must be attained on each run to a region. A region, from a grocer’s standpoint, is an area that has customers with a certain profile, or takes a certain amount of time of travel. A grocer must determine if deliveries to a region will be profitable or not. If the grocer decides that each dispatch of a delivery truck (or “run”) to a region must result that revenues must exceed operating costs by \$X, then all the grocer needs to do is input the \$X profit figure into the Mandatory Profit dialogue box of this simulation. The dialogue box is a data input box on the logistic computerized interface that I have developed. Additionally, the Mandatory Profit can be specified according to different regions, allowing myriad possibilities for different profitability attainment scenarios.

The expected profit margin can be input into the application. This percentage is calculated in conjunction with the Mandatory Profit and the Delivery Charge to ascertain whether the initiative can be profitable. The Profit Margin can be varied from 0.1% to 3% of the value of the groceries delivered.

The Delivery Charge is another variable that can be input. The grocer can specify any amount of delivery charge, from zero to as high as he or she would like. This delivery charge is added to the calculation of each order generated and is used to calculate the Mandatory Profit.

Another variable that can be added to each simulation scenario is the Minimum Dollar Amount. If a grocer feels that it is not worth his while to deliver anything less than \$20 of groceries, the merchant could input that option into the simulation.

Succinctly stated, an objective of the simulation is the determination of the conditions where an online e-grocer (or a grocer who is taking orders by a telephone) will reach a predetermined amount of profitability.

When a grocer uses the logistical application, he or she will be in a significantly better position to decide whether to initiate a home delivery service, or at least make a more calculated decision about whether more costly analyses are justified or not.

Although the logistical simulation application contains sophisticated algorithms, and performs computational tasks, a main purpose of mine is to create an application that is intuitive and easy to use. This I have done.

### **Methodology**

This presents a spatial decision support system for the delivery of groceries from fixed “brick and mortar” locations to customers’ homes. The spatial decision support system (SDSS) will be demonstrated with a simulation. The simulation will perform the following functions.

- Determine the mix of variables that are necessary for the online grocer to generate a profit while delivering groceries.

- Tell the total profit that can be generated through deliveries, given a certain profit margin.
- Determine the amount of trucks necessary to deliver to the customers.
- Show what regions normally reach a profitability margin, and at what times they do so.
- Provide very good, medium, and poor profitability scenarios using the simulation application I developed.

The simulation includes identification of the algorithms required to implement the SDSS. When combined with reasonable data inputs, the information flow and algorithms will allow for the identification of which geographic settings the SDSS can be successfully deployed, and which are unlikely to be met with success. Even if no geographic settings are indicated as being likely candidates for an actual SDSS of this type, the simulation will be a success as it will indicate to investors that profit margins in the contemporary grocery industry are insufficient to take advantage of the technology and online ordering and store distribution of groceries to customers.

It is assumed that the grocery store has surveyed its current customer demand base to determine the amount of groceries the customers will order from home each week. In other words, the grocery store management is assumed to have reasonable expectations of market penetration by neighborhood under various pricing schemes.

The geography of the delivery market will be show as follows.

- An urban region will be depicted on a map.
- A pattern that consists of honeycomb regions will be overlain on the map (Figure 1).
- The home store will be located at the center of the honeycomb area. In Figure 1 diagram, the store is located in the center blue hexagon.
- The hexagonal regions will be identified by capital letters. The home store in the center region will be in region “H” meaning “home”.

- Each customer will be associated with a hexagonal region.
- A random number generator will select customers for use in the simulation.
- The simulation will compress time.
- The contiguous hexagonal pattern will continue outward from the store, in a radial manner (Figure 1).

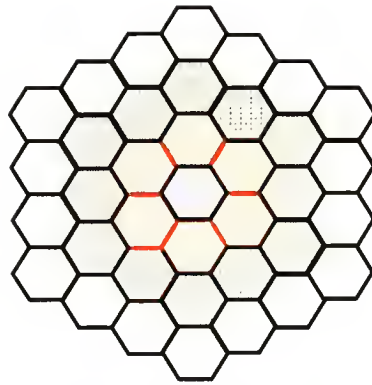


Figure 1. Hexagonal layout

## LITERATURE REVIEW

Although the main purpose of this dissertation is to emphasize the geographic significance of delivery zones in an e-commerce enabled grocery delivery strategy, the work necessarily encompasses more than geography and GIS (geographic information systems), and this multi-disciplinary approach is reflected in the literature review. An important part of this section is “Grocer web Site Design Issues.” This is because, although the logistic application that I developed is run through Microsoft Excel™, the application can be used as a web service, which basically means it can be used by computers at remote sites for a fee. The section about artificial intelligence is included to better acquaint the reader with potentially important grocer decision-making tools such as intelligent agents that could traverse networks and read mobile computers in delivery trucks. The Literature Review would be incomplete without the incorporation of the two sections that include GIS for traffic flow simulation, vehicle routing, and logistics. These concepts are the important technologies for grocers who want to optimize their trucks’ routes, which can result in more satisfied customers because of timely deliveries, and less fuel and manpower expenditures. The manner which polygons, points, and lines are represented on a GIS along with the way data is depicted near these geometric figures should be important to grocers who deliver through a GIS interface so as not to include superfluous data, or omit important data to delivery, operational, and managerial personnel. A review of the literature about these concepts is also included in this section.

### **Online Grocer's Failures, Difficulties and Possible Solutions**

There is a lot of supporting and relevant literature that, when combined, can provide the building blocks for the utilization of delivery zones in geographic enterprise optimization systems (GEOS) for online grocers. After reviewing the below-described literature, the solution proposed in this dissertation for online grocer deliveries is not only necessary, but also feasible.

In 2000, at the minimum seven pure online grocers were operating in the United States. By the end of that year the only two that remained were Webvan and Peapod. In an ominous statement, Ring and Tigert (2001) said, “no company has ever made a profit in this (pure online grocery) business.”

Perhaps the most visible of all grocery delivery companies' demises is that of Webvan, the multi-billion dollar venture that started optimistically, but ended soon after it began. Much literature exists concerning the quick bankruptcy of this and other online grocery delivery companies (Partch, 1999; Saccomano, 1999b; Tweney, 1999; Briody, 2000; Bubny, 2000; Sanborn, 2000; Evans, 2001; Heun, 2001; Partch, 2001; Ring, 2001).

The founder of Borders Books, Louis Borders, created Webvan in 1999 to deliver groceries and other household items to homes within 30 minutes of receiving the order (Tweney, 1999). George Shaheen, a managing partner of Anderson Consulting, whose father was in the grocery business, was the CEO in charge when Webvan went bankrupt (Partch, 2001). There was much hope – and skepticism – when \$11 billion was raised in Webvan's 1999 initial public offering (Evans, 2001). The hope was that Webvan, optimistically called the spot where “the internet meets your doorstep,” could capture a portion of the annual \$650 billion United States online grocery, prepared food, and

drugstore market (Sanborn, 2000). Of this amount, \$450 billion of food is purchased annually in the United States (Ring, 2001).

It was a grand scheme that depended on a network of large and expensive automated warehouse distribution centers as springboards for the delivery vans. Partch (1999) wrote in “Home Delivery, Another Problem Solved,” that a single distribution center would have the capacity to dispatch as many groceries as 20 supermarkets. The distribution centers were approximately 330,000 square feet each. The first distribution center was located in Oakland, California; and the company planned to build another 25 similar centers in other cities (Ring, 2001).

A portion of Webvan’s plan did have a customer allure to it. The fledgling company offered 24-hour free delivery (with orders more than \$50) with prices up to 10% cheaper than brick-and-mortar grocers (Partch, 1999).

Besides the money raised from the IPO, deep-pocketed investors like Knight-Ridder, CBS, and Softbank sank money into the company (Saccomano, 1999b). But, contrary to stockholder and other investor optimism, literature shows that many people were also pessimistic about Webvan’s viability. Dan Rabinowitz of Peapod Inc., another online grocer, called Webvan’s business model “a lot of smoke and mirrors” (Saccomano, 1999b). In the same article, grocery consultant Cristopher Hoyt shows his doubt by saying that Webvan would not be able to solve the perishable food distribution problem, and that even if they can deliver the dry foods efficiently, the grocery market for dry foods is being supplanted by cheaper super centers.

Webvan’s investors and managers would have benefited from Michael Brown’s commentary on automated grocery distribution centers. Brown said in 1993, “the best

strategy at present may be to postpone investment in a centralized warehouse with high levels of automation, correspondingly high capital costs, and a lengthy payback period” (Browne, 1993).

Miles Cook, vice president of consulting firm Bain and Company, said, “online grocery is a murderously difficult market,” (Heun, 2001). Evidently Cook, Rabinowitz, Hoyt, and other skeptics were right because only 20 months after its inception, Webvan fired 2,000 employees and filed for bankruptcy (Evans, 2001).

It seems that the less-than-optimal business model employed by Webvan is not the only factor to blame for that company’s demise. Paul Bubny (2000) explains that customer sentiment regarding online purchases is an inhibiting factor. His PricewaterhouseCoopers’ study revealed that 21% of internet users would never purchase groceries online. This says nothing of the percentage of current non-internet users that will not buy groceries online in the future when they begin to use the internet. Bubny (2000) calls grocery shopping a “care-giving function,” and says consumers are not ready to allow a “detached process such as online shopping” to supply their food. Further, a survey conducted by NPD group revealed that a mere 2% of consumers would buy groceries exclusively from an online site.

The same article, however, states that, with proper incentives, customers can be convinced to buy groceries online. Respondents to the PricewaterhouseCoopers’ survey stated that price is their main concern when buying online groceries, which includes free delivery. This implies that if other factors such as freshness and rapid delivery are fulfilled, consumers may be persuaded to buy groceries online if the price is right.

Mainstream grocers are not turning a blind eye to online grocers. In fact, the threat posed to large grocers' markets by smaller online grocers is real. Alan Mitchell says that even a 5 to 10% rise in home grocery shopping could "severely dent" a superstore's underlying profitability (Mitchell, 1999). This statement can be especially portentous to brick-and-mortar grocers if they consider that overall online purchases are estimated to keep on increasing (Killgren, 1999). Evidently with this in mind, large United States grocers like Albertsons and Safeway are initiating brick and click grocery business models (Briody, 2000). Safeway and Royal Ahold, a Dutch conglomerate, both formed joint alliances with pure online grocers. By joining with foundering Peabody, Royal Ahold saved Peabody from probable bankruptcy. Safeway invested \$30 million in Groceryworks.com. Not long after Groceryworks.com built two fulfillment centers in the south-central United States, the company closed them down. Safeway subsequently decided that filling online orders from its store shelves was a better model and began doing so (Heun, 2001).

Albertsons is moving forward with a purely internal brick-and-click delivery initiative. Possibly as a result of Webvan's closure, Albertsons' online sales in the Seattle area increased 300% after Webvan stopped operating. Like Safeway, Albertsons fills orders from its stores' shelves. Safeway is also implementing a fleet management system to better route their trucks and more closely monitor driver and vehicle performance (Barnes, 2002).

Ring and Tigert (Tigert, 2001) enumerate six groups of dissuasive factors contributing to customer skepticism toward online grocery purchases. According to them, place, the first factor, is important because customers like to be in a place where they can

touch and smell the merchandise. The next group, product, says that online grocers may not have enough stock keeping units (SKU) that the customer desires. An SKU is essentially an individual type of product. Third, value, is “more bang for the buck,” which is often sacrificed by relatively high delivery fees. Service comes next. When a customer visits a store, there are hopefully more knowledgeable and courteous employees present than a single delivery truck driver. Communication, the fifth factor, comes in the form of advertisement or notification to the customer. Ring and Tigert (2001) do not expound on how this group is an inhibiting factor for online grocers. The sixth group, technical problems, appears in the form of wrong orders or late deliveries, which can ruin online grocers.

Another problem, as told by McKinnon and Tallam (2003), is the security of delivering to homes, especially when the home is unoccupied. Groceries can be delivered four ways to unoccupied residences. 1. The driver can enter the house. 2. A drop box is available. 3. Another customer-designated location is available. 4. The goods are left at a separate local agency, which delivers the groceries when the customer is home.

The article does say that overall, unattended delivery of groceries is relatively secure when compared to the unattended delivery of more valuable items. Of course, the worth of the goods matter little if the cause of the security breach is the delivery driver having access to the interior of the home. The article does say that although the unattended groceries may not be stolen, the fact that they are left visible implies that the homeowner is not present which can invite burglary into the premises.

McKinnon and Tallams' (2003) security implications are relevant because a significant amount of the prospective home grocery delivery market may not be online

because of the security implications. In the same article, the authors list different ways groceries could be left at an unattended home. Those ways are a fixed interior box with three compartments of various temperatures with a keypad-lockable door; a fixed external box connected to an external wall; a mobile box delivered to the customer and connected to a cable to the house; and communal collection boxes. The communal boxes can be of various types. Primarily they are in a central place like a popular parking lot or near a train station. Communal boxes can have numerous compartments, each with its own lock and changeable code to open the lock (McKinnon and Tallam, 2003). When deciding on a grocery delivery model, consideration should be given to each of these drop-off strategies to decide which would probably work best given the catchment neighborhood, type of customer lifestyle segment profiles (LSP) catered to, and logistical strategy used by the online grocer. Of the LSP databases used for this type of analysis, MOSAIC, ACORN, and NDL's Lifestyle database are three of the most highly regarded (O'Malley, 1997).

The type of drop-off method is not unrelated to the "skill" the drivers have in delivering the groceries. Skill here relates to the ability of the drivers to learn routes on the fly. If an online grocer delivers to individual residences, especially when guaranteeing delivery within an hour, it becomes highly unlikely that any two routes taken within, say, one or two days, will be exactly the same. Michael Haughton expounds upon the relationship of uncertain daily deliveries with the drivers' ability to learn new routes on the fly (Haughton, 2002).

Haughton (2002) states that fluctuating demand can result in inefficient delivery and dissatisfied customers. He refers to a "learning burden," and proposes a correlation metric

to assess the familiarity of a driver with certain rectilinear delivery routes. Because my research is focused on solving the problem of individual residence delivery, which presupposes daily fluctuating demands, Haughton's (2002) literature is relevant to this dissertation.

Cross and Neil (2000) call online grocery shopping a "booming global phenomenon." Obviously this statement does not seem to include the plights of the failed United States online grocers. Evidently, these authors are referring to online grocers in Great Britain, Scandinavia, and Iceland that are not doing as badly as those in the United States. Optimistically, however, Cross and Neil tell how convenience is a driving factor toward the success of online grocers. They mention how technologically savvy customers are the most profitable ones because they are more inclined to shop online. The article also says how employers can use online grocers as a fringe benefit to their employees. The employer can pay for the delivery service to the office where the employees pick up their groceries when they leave work.

Another factor that could provide inertia toward successful online grocer businesses is UCCNet. This is a subsidiary of the Uniform Code Council, which is the organization that developed the universal product code. UCCNet allows e-commerce companies to register their supply-chain related data. UCCNet is an internet trading network that could benefit buyers and sellers of food, beverages, and other items (Violono, 1999). Because the network aids collaborative planning, forecasting, and replenishment, smaller online grocers who use UCCNet should be better able to procure needed stock in times of unexpected spikes in online purchases. More literature pertaining to UCCNet is reviewed below.

Catering to the growing United States Hispanic market is an online grocer called LatinGrocer. Saccomano (1999a) states that by 2009, 40% of the United States population will be Hispanic, creating a very large grocery market. LatinGrocer's unique point is that its services are also offered in Puerto Rico.

An effort to identify the success factors in e-grocery home delivery was made by Punakivi and Saranen (2001) using simulation. The article supports the intent of this dissertation by explaining that the lack of a proper logistical home delivery infrastructure is the main deterrent to a successful online grocer.

Using Finland as an example, Punakivi and Saranen (2001) concluded that home delivery can be as much as 43% cheaper for customers when compared to the customer driving to the supermarket. Punakivi and Saranen (2001) write that the cost to deliver groceries will be less when the delivery time window is larger and customers live in densely populated areas. These are intuitive factors. What might not be so intuitive, however, is that the number of needed delivery vehicles increases by 250% when a manned delivery model (when the customer must be home) is used instead of an unmanned model which uses drop boxes. Tanskanen and Punakivi (2002) write that the only factor more costly than the deliveries in a manned home delivery model is the actual picking and packing of the groceries. One reason for the higher manned delivery costs is that up to 60% of the packages might be undeliverable because of people not being home. In Great Britain, some main grocers are using unattended delivery methods. In Finland, grocers are using shared multi-temperature drop boxes for unattended delivery. A factor that affects the costs and profitability of the shared reception box model is the number of separate compartments in each box (Punakivi and Tanskanen, 2002).

It is important to note that online grocers might have to operate somewhat contrarily to flexible production techniques. This is because although flexible production uses strategies such as just in time deliveries (Browne, 1993), online grocers who precisely forecast a significant proportion of their deliveries should consider pre-packing those groceries to save time during busier order packing times. Shorter delivery time windows notwithstanding, the ability for customers to choose what time the groceries are delivered is another factor that increases delivery costs. In other words, given a 40-minute delivery time window, the model that allows customers to choose what delivery time window is the more expensive delivery method (as opposed to the grocer deciding what delivery time window to dispatch the truck) (Punakivi and Tanskanen, 2002).

Speaking of delivery costs, online grocers must consider the tradeoff of shipping from fewer sites, which increase delivery costs (Browne, 1993), or dispatching the groceries from more outlets, which could increase the packing costs. Browne writes that products with relatively low value densities should be distributed by local delivery. This would apply to most groceries.

Gorr, Johnson, and Roehrig (2001) talk about the difficulty of home delivery services and how GIS can help with delivery solutions. They describe the constraints imposed upon delivering hot meals to residents home. Their research is applicable to this dissertation because online grocers may offer hot delicatessen foods delivered to homes. Indeed, it might be this hot (and cold) food service that helps the online grocer to gain market share. But, as this particular article states, the time window that exists to deliver these foods is greatly decreased because of the necessity to maintain very hot or very cold

temperatures. Gorr, Johnson, and Roehrig (2001) write that 45 minutes is the maximum allowable delivery time for these deliveries.

Gorr, Johnson, and Roehrig (2001) also discuss the feasibility of using a spatial decision support system (SDSS) for delivering hot meals. The combination of GIS, algorithms, and managerial judgment are parts of SDSS. A particular problem the authors address is the situation created when customers change addresses. The SDSS algorithms should be robust enough to handle this type of change (Gorr, Johnson, and Roehrig, 2001).

One approach that online grocers might pursue when considering their overall strategic plans to deliver groceries is to look at the composite customer equity that the delivery regions encompass. Customer equity, which is often used as an augmentation to brand equity, is the sum of the lifetime values of all of the customers a business has (Niraj, 2001). If, when contemplating a delivery plan, the customer equity calculation does not look as if it could be increased or even sustainable, it might be advisable to rethink the grocery delivery plan. Some aspects to look at when determining the sustainability of customers are complexity factors and efficiency factors of those customers (Niraj, 2001). Succinctly stated, these two factors are antithetical forces. Whereas complexity factors, such as difficulty fulfilling a grocery order, decrease a customer's lifetime value, efficiency factors, which make a delivery to a particular address easier, can help increase the lifetime value of the customer.

### **Spatial Decision Support Systems**

Research about using GIS as an integral part of SDSS began years before the above-noted article by Gorr, Johnson, and Roehrig (2001). Crossland et al. (2001) studied the

effectiveness of using GIS in SDSS to see if the time used to solve problems could be significantly decreased. The article reinforces the important point that most business data have “one or more spatial components.” Three of these components, as stated in the article, are relevant to online grocer business models – customer addresses, delivery vehicle locations, and site selection. Calling GIS a “highly evolved technical toolbox,” the article, says that GIS should not only be used to find solutions to problems, but also to guide the users to problems that might have been unforeseen before the adoption of a GIS-enabled SDSS (Crossland, 1995). The worth of decision support systems (DSS) in general is stated by (Vlachopoulou et al., 2001). They say that DSS “couples the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions and to support managerial judgment” (Vlachopoulou et al., 2001). The value of spatial aids to managerial judgment should not be underestimated. Thrall (1995) endorses the value of using GIS to optimize judgment in managerial decision making. Thrall writes that, “...using GIS to improve judgment is a crucial stage in reasoning with GIS because it links GIS to the market economy.” Thrall expounds on his GIS-facilitated judgment maxim by describing the value of business geography. Thrall said, “Business geography integrates geographic analysis, reasoning, and technology for the improvement of the business judgmental decision. Without the demonstrated ability to improve the business decision, there is no business geography. This differentiates business geography from the traditional descriptive or explanatory objective of economic and urban geography” (Thrall, 2002).

Gorr et al. (1995) tell how a GIS-enabled SDSS can allow decision makers, or their assistants, to use databases in real time. This is of course important for online grocers that

employ metamorphic delivery zones because, as this dissertation will show, it is when a delivery zone reaches a certain profitability threshold that the truck should be dispatched to that zone. A decision maker, or his or her assistant, must be able to make the real-time decision to send the truck. Gorr et al. (1995) show that spatially related decisions can be made faster and with less error when SDSS are used. Supporting the assertion that deliveries should be made only after a certain profitability level has been reached is Niraj et al.'s (2001) research that says a company should "eliminate transactions that do not add value." If value to a company (considered here as profitability) is not created by a delivery to a zone, then perhaps delivery to that zone should be deferred to a later time when the value of that zone increases. Care should be taken that this strategy does not result in dropping customers who might be unprofitable in the short run, but might become valuable customers in the foreseeable future (Niraj et al., 2001).

A SDSS incorporates GIS with a database management system (DBMS) and peripheral software tools that allow interaction with the analysts and other users (Tarantilis et al., 2002). Tarantilis et al. call SDSS a "new scientific area of information systems applications." Possibly, the relative newness of SDSS is in part the reason that little if any literature exists about the utilization of this technology to successfully solve the problem of delivering groceries that are purchased online. I will demonstrate in this dissertation that spatial decision support systems can be the difference between the success and failure for any online grocer of significant size.

The importance of routing information systems is underscored by Browne as he says that the end of the era of "cheap freight" transport is here, where reliability used to be attained without modern information systems (Browne, 1993).

Tarantilis and Kiranoudis (2002) use SDSS to solve a vehicle routing problem (VRP) using the backtracking adaptive threshold accepting (BATA) model. The constraints posed in these authors' research mirror those that would be inherent in a typical grocery delivery situation. They are minimize the distance traveled, do not exceed the capacity of a vehicle, and, one vehicle delivers each customer's order. Although the article does not specifically mention web services, it does say that reusable software components are important parts of a SDSS. Because, more recently, the importance and viability of web services (for example, services created by the .Net platform) have gained mainstream exposure, the plausibility of creating a component-based SDSS is greater than it is without using web services.

Tarantilis and Kiranoudis (2002) give a detailed and graphical explanation of all the components of a SDSS. ArcView is the GIS used. BATA, in conjunction with the Dijkstra algorithm, determines which vehicle should deliver to which customers and the order that it should do so. BATA is a "metaheuristic" method, meaning that it relies on more than one heuristic to arrive at a solution. The article states that the SDSS is used by Athens, Greece taxi companies, newspaper companies, and for meal delivery. Benefits attained by using the SDSS include the ability to make semi-structured or unstructured vehicle routing decisions, transport cost reduction, and better control of distribution (Tarantilis and Kiranoudis, 2002). Also, when routing decisions are made using a SDSS, the decisions made might be more intuitive if some sort of multimedia capabilities exist within the system. Cartwright and Hunter explain how decision support systems can be enhanced by the incorporation of multimedia. These authors say, "users of geographic information need far more than the printed map, and they are likely to need rapidly-

produced and well designed spatial displays combining a number of different types of data” (Cartwright, 2001).

As pertains to this dissertation, the key words expressed by Cartwright and Hunter are “rapidly-produced...spatial displays.” Another notion proposed by these authors is that although the incorporation of multimedia into GIS is very valuable, care must be taken to not “overwhelm” the users. Ogao and Kraak (2002) agree with this by saying that animation can distract the users if it is overused. These cautions should be adhered to by online grocers who incorporate delivery zones into their geographic enterprise optimization systems.

Ralston, Tharakan, and Liu (1994) espoused the virtues of SDSS before GIS was considered a mainstream technology. The authors said that GIS must be merged with spatial analysis tools for GIS to be used to its fullest potential. Agreeably, GIS alone, without being augmented with tools such as simulation or artificial intelligence, is a powerful technology but remains a mere shell of what it could be when used with these tools. In Ralston et al.’s article it is said that transportation networks are comprised of physical and logical links. Physical links are the actual roads, railways, or inland water routes. The Logical links are points along the physical links for deliveries, pick ups, and inter-modal transfers. Physical links of the same type can be divided into classes depending on factors such as cost, capacity, and speed. Paths between a source and destination always have both physical and logical links (Ralston, 1994).

Nasirin and Birks expound upon the types of SDSS used by retailers in Great Britain. Knowing customer proximity to the store and those customers’ purchasing behaviors are two common functions performed when SDSS is used by retailers. The literature states

that one reason retailers are adopting GIS-enabled decision support systems is because of the increasing availability and portability of spatial data which often exists on compact disks. Despite this growing adoption of GIS by retailers, there has been little research about the methodologies that retailers employ when using GIS to make decisions, even though successful usage of GIS by retailers involves “enormous numbers” of factors (Nasirin, 2003). An important point made in this article is that GIS should be used by retailers to determine who the competition is and where they are located.

Keenan (1998) says that GIS is a technology that can “take advantage of other technologies,” when used to make routing decisions. Keenan also states that straight-line distance is insufficient for routing calculations, and that time traveled is a better indicator of the route. Using a decision support system (DSS) is important when ascertaining the best route because sometimes the best route may actually look circuitous (Keenan, 1998). According to Keenan (1998), this is where the “soft” constraints, such as decision-makers’ judgment, apply. The importance of the decision-makers’ input is why solutions to routing problems require the use of DSS more and expert systems less (Keenan, 1998). Many times data and information applicable to the routing problem may already be in the corporate management information system (MIS). Often information such as customer demand and vehicle size is business-specific, thereby requiring a customized link to the data from the GIS (Keenan, 1998). Because spatial data is getting less inexpensive to purchase, the availability of comprehensive highway databases will become more readily available. Also, according to Keenan, highway data within a GIS when used in with sophisticated management science routing algorithms can result in useful SDSS.

Genetic algorithms, although not strictly a spatial decision support system component, are intriguing problem solvers that can help with difficult and time-consuming geographic problems. Clarke (1998) believes that Genetic algorithms (GA) utilization will soon become more prominent in GIS. Genetic algorithms use a “Darwinian” method to find feasible solutions for problems by forcing solutions to “evolve” by allowing only the “strongest” genre of variables to “survive” repeated iterations through the problem. Chromosomes, consisting of genes, which themselves contain alleles, “evolves the population of solutions by repeated selection and mating” (Van Dijk et al., 2002). Van Dijk et al. demonstrate the use of GA to solve a map labeling problem. Some of the dynamics of the GA problem solving method are Selection, which means better parents produce fit children. By using tournament selection – iteratively choosing parents until n sets of two parents are chosen - a set of parents is only chosen if their children are fit. Reproduction, which means each set of parents produce two children. Crossover refers to a certain amount of genes from each parent which are imbued into the children. Replacement means some less fit children are exterminated to make room for other stronger offspring. Finally Termination occurs when, at some point, the population “converges,” or become as close to optimal as possible.

Obviously, this is a very abstract explanation of GA. As a concrete example, Van Dijk et al. show how map labels are optimally placed using GA while specifying the direction of the label in respect to the city, degree of congestion of labels, and how large the labels are in proportion to city population. Online grocers should investigate the utilization of GA in their routing and customer selection optimization strategies. This is because if delivery time is considered a scarce resource, the profitability of customers

becomes a paramount issue when deciding routes. Customers can be chosen using GA by “natural selection” using profitability as one of the gene traits, as described above.

### **Online Retailer Geographic Issues**

“Microscale” competitor analysis is possible with GIS (Sadahiro, 2001). Sadahiro (2001) uses this approach as he looks at retail location in Japan and discovers that stores are usually clustered around railroad stations.

Clustering, although often used to denote a sort of condensation of entities within a region, is also a group of techniques use to analyze complex geographic data to ascertain if spatial relations exist or not. Pattern spotting and data mining are two ways to determine the presence or absence of clustering (Murray, 1999). While looking at two types of clustering problems, the median clustering problem and the central point clustering problem, Murray discovered that the median clustering problem requires less computational power to solve than the central point clustering problem.

An aspect of retail clustering that pure online grocers (those without a brick-and-mortar store) should consider is that they might not be able to capitalize on the important aspect of being within customers’ comparison shopping region. Sadahiro (2001) recognizes this important factor and develops a probability density function, which quantifiably tells the degree of agglomeration of retail stores of the same classification. One reason stores in the same classification locate near each other is to provide customers with the opportunity to shop comparatively (Sadahiro, 2001). Although this is not the only force that results in retail agglomeration, it should be recognized as a force that might take customers away from online grocery sites. Guy describes comparison shopping as one factor to consider when investigating the grouping of retail stores. He

says that comparison shopping has an “enjoyable” aspect to it (Guy, 1998). Can comparing prices of competing online grocers online be “enjoyable?” This question is worth considering by online grocers.

Baker addresses another problem that is encountered by online retailers. He says that online retailers do not adequately consider central places when selling online. This is because the fast speed of most internet communications lends itself to the underestimation of the importance of spatiality in cyberspace. He calls the failure of retailers to comprehend distance minimization strategies such as the gravity model “a major barrier to successful marketing and profitability for internet retailing” (Baker, 2001).

Recently, consumer activity patterns have been given greater scrutiny by retailers. Consumer activity patterns could be relevant to online grocers for various reasons. For instance, activity patterns could help online grocers decide whether to deliver to the home or use communal drop boxes. Decision tree induction, which is used by artificial intelligence and statistics, has recently been said to be useful to help model activity-based models (Arentze, 2003). Albatross models model travel demand using a rule-based decision tree. Arentze (2003) says that decision tree induction can be useful for modeling spatiotemporal behavior, such as the behavior exhibited in activity patterns. Activity-based travel behavior (ABTB) is the term coined for this type of activity monitoring (Frehida et al., 2002). The concept of “space-time paths” is covered by Frehida et al. (2002) in their article about ABTB. According to these authors, space-time paths can help explain, predict, and plan for past and future activity patterns of commuters.

The reason for the attention given to activity patterns is that previously, retailers looked at discrete trips when calculating the amount purchased by consumers. The current consumer trend, however, is to engage in multi-stop “tours.” The itinerary of these tours is influenced by retailer policies, travel costs, and other services and entertainment consumed on the tour. These “hybrid” multi-stop tours are blurring the distinction between retail shopping trips and other types of trips (Roy et al., 2001).

Online grocers might be interested in the efforts to classify hybrid trips. Some classifications enumerated by Roy et al. are tours that a) start and end at home, b) start and end at home with a work stop, c) start and end at work, and d) tele-orders, which are orders placed over the telephone.

Of course online grocers would be interested in the fourth hybrid trip category – tele-orders. But there should be ample reason for online grocers to concern themselves with the other three categories as well. This is because, according to Roy et al. (2001), consumers consider aggregate properties of tours. This means that if groceries ordered online can become part of the tour (by picking up the groceries at communal drop boxes), or might not become part of the tour (thereby saving the consumer time by having the groceries delivered at home).

The duration and sequence of activities undertaken during tours is important; so much so that various models of activity duration during trips have been developed. Two of the models are the unconditional and conditional risk models. Some of the many determinations made by Popkowski et al. (2002) when using these models are shopping after work decreases with age; single people shop often after work; poorer people are more likely to indulge in leisure after work; after leisure people are likely to conduct

personal business, then shop. Online grocers could look at these determinations when deciding web page content, delivery routes, and more.

Task allocation is similar to activity patterns. Task allocation is the allocation of subsets of tasks by household members while considering context variables such as constraints and imperatives relevant to those household members such as car availability, and urgency (Borgers et al., 2001). Other issues to consider when attempting to predict if a household member will perform a certain task are whether the task is mandatory or discretionary; or is shared or performed alone. Borgers et al. (2001) assume that task allocation can be correctly simulated. Although this assumption is debatable, it may be worthwhile for online grocers to consider situations when household members must perform a mandatory task, such as shop for groceries, while at the same time be constrained by only having one vehicle because a spouse or child is using the sole car when the shopping trip must be performed.

The logistical requirements of online grocers are different than that of brick-and-mortar supermarkets. Although there is an overabundance of literature about retail supermarket logistics, there is little that applies solely to the logistic requirements of online grocers.

Third party logistic firms (3PL) can supply all or a portion of a companies' warehousing and distribution needs (Balakrishnan, 2000). This could be a novel idea for online grocers who do not want to pack and ship their own groceries. It might also be an innovative service provided by a new kind of 3PL that caters exclusively to grocery delivery. A difficulty in using 3PLs for grocery delivery could be in the compensation scheme. There are many variables, such as type of goods (frozen or hot),

weight, changing demand, and expedited foods, to name just a few. According to

Balakrishnan (2000), achieving fairness in compensating multiple distributors can be challenging. Fee tables usually are made to calculate delivery compensation. Two primary ways to determine fee values are tariff and cost-based approaches. The former gauges the delivery compensation by geographic regions, while the latter estimates the delivery costs using a function of distance and weight of the goods (Balakrishnan, 2000).

Microsoft's Solver contains linear programming capabilities that can be useful to even smaller online grocers that are developing fee schedules or in-house delivery driver compensation.

### **Grocer Web Site Design Issues**

Wang and Gerchak (2001) support the importance of stock keeping units (SKU) in the decision of a customer to shop at the store. Of course, customers prefer stores with more SKUs. Therefore, a tradeoff has to be reached when allowing greater "virtual" shelf space for more profitable items or showing more SKUs per web page.

Wang and Gerchak's (2001) research discusses the relationship between demand and the allocation of retail shelf space. Because, according to the article, demand increases when more shelf space is allocated to a product, an online grocer that more prominently displays the higher profit items on its web site might have lower delivery costs relative to the cost of the groceries delivered. This issue deserves more research. Interestingly, Wang and Gerchak (2001) say that for any two identical retailers, the total profit made between them depends only on their total inventory level, not on how the total inventory is allotted between them. This could be significant when two online grocers, or an online grocer and a brick and mortar grocer compete in the same market area. The word

“identical” can be ambiguous. But, if identical is defined as the same amount of SKU’s, then, if this proposition is correct, an online grocer that has the same amount of SKUs as a brick and mortar grocer should have a reasonably good chance of selling as much as the brick and mortar store. In “Designing an Effective Cyber Store Interface,” Kim and Eom (2002) talk about the importance of clearly showing on a web site that risk-free and on time delivery is offered. They propose four elements of customer satisfaction. The elements are product and/or service, support, bad experience recovery, and extraordinary service. The factors of risk-free and on time delivery could be classified under any or all of Kim and Eom’s (2002) elements of customer satisfaction. Throughout their article it is said that an e-commerce site should allow customers to comparison shop. Taken in conjunction with showing the greatest possible amount of SKUs on a web site, if a site allows, or even encourages customers to compare the prices of the host grocer’s SKUs with the prices of other grocers products (online or not), customer satisfaction and sales might increase.

### **Artificial Intelligence**

The study of neural networks is a branch of artificial intelligence that pertains to roughly mimicking the brain to make calculated decisions. Literature exists that shows the attempts to include the decision-making power of artificial neural networks (ANN) in GIS. Although I have not located any literature that specifically uses ANN to determine delivery routes for online grocers, ANN has been used with GIS for other types of applications, which shows the feasibility of using these technologies together.

The predictive power of the combination of GIS and ANN to forecast land use changes in Michigan is documented by Pijanowski et al. (2002). The article says the use

of GIS and ANN can “aid in the complex process of land use change.” Also, “ANNs are powerful tools that use a machine learning approach to quantify and model complex behavior and patterns.” This is precisely the type of functionality online grocers need in order to predict demand and create tentative delivery zones to better prepare for that demand. Pijanowski et al. state that because of the spatial nature of the variables, the incorporation of ANN with GIS is “essential.” The same should hold true for an online grocer’s logistical dynamic routing application.

Black (1995) writes that using ANN with the gravity model. He uses a gravity artificial neural network (GANN) to show commodity flows between nine United States census regions. Using as input values regional flow of commodities, regional flow attraction, and interregional distance, he discovered that the accuracy of the gravity model improved when he moved from the unconstrained (conventional) gravity model to the GANN. Black concludes that flow modeling can be “revolutionized” by using the GANN model. What Black’s research contributes to the purpose of this dissertation is the clarification that ANNs increase the flexibility and usefulness of not only GIS, but also spatial modeling in general.

Black (1993) states that an industrial firm must make three decisions after it has decided to operate. 1. Where to locate, 2. What technology to use, and 3. What the scale of production will be. Although Black was mainly referring to manufacturing firms, his three points can also apply to an online grocery initiative. The technology inferred by Black can include GIS, computer simulation, SDSS, intelligent traffic systems and more. Scale could refer to the scope of the business model as referring to delivery methods and delivery zones, while firm location is of course where the grocery store and its

distribution center(s) are located in comparison to the customer base. These three factors should be considered within the entire online grocery delivery model.

It should be noted that a concern of both Pijanowski and Black in the above-mentioned research about ANN and spatial technology is the problem of spatial autocorrelation. Research exists addressing this problem. One example is from Duckham (2000) who discusses “error sensitive GIS.” Relevantly, this literature also touches on the realm of artificial intelligence because it uses induction, an established artificial intelligence technique. According to this article, “an inductive learning algorithm should be able to automatically deduce rules that embody the patterns in that data...” According to Gahegan (2000), inductive machine learning is gaining popularity in the geographic community.

Interestingly, even though, according to Duckham et al. (2000), the inductive algorithm deduces; it does not induce, this literature is noteworthy because it endorses an artificial intelligence (AI) solution to spatial problems such as autocorrelation that could be otherwise intensified by the incorporation of another AI solution, namely artificial neural networks (ANN). Additionally, because of the low profitability and labor intensiveness of ascertaining the amount of error in geographic data, the article says that there probably will not be many companies strictly concerned with quality issues in geographic data. Duckham et al.’s (2000) research therefore recommends the inductive learning algorithm because it is a relatively low cost way of ascertaining spatial data quality.

Neural spatial interaction models are somewhat related to gravity models. Three gravity model input variables relate to measures of “origin propulsiveness, destination

attractiveness and spatial separation” (Fischer, 2002). Neural spatial interaction models relate to gravity models not only because they expedite mathematical modeling, but because they are adaptive enough to “deal with incomplete, inaccurate, distorted, missing, noisy, and confusing data” (Fischer, 2002).

Although the field of artificial intelligence includes technology such as expert systems, neural networks, and fuzzy logic, intelligent agents possess a particularly promising niche in the field of online grocery supply chain optimization and visualization. Because of their ability to “automatically” scan intranets, extranets, and the internet, intelligent software agents (or just “intelligent agents”), or bots, can be programmed to periodically monitor databases, data marts, and directories. The gleaned data could then be made available in a more informative format, such as in GEOS-enabled online grocery logistic solutions.

Although using bots to collect data can be difficult (Fontana, 2002), companies, such as SAP, are aggressively pursuing the utilization of bots in ERP (enterprise resource management) and SCM (supply chain management) solutions. Steve Ranger tells how SAP is using bots to gather supply chain partner data and make the resulting information available through portals (Ranger, 2001).

One of the forerunners in intelligent agent research is the Carnegie Mellon University. A look at their intelligent software agent website gives an inkling of the branches of this field of artificial intelligence (Carnegie Mellon, 2001).

The Carnegie Mellon site shows a few bot technologies that could be of particular value to online grocery logistic plans. Local area discovery and multi-agent learning are

two such technologies. In multi-agent learning the bots learn in “dynamic environments” such as that which exist between different networks of companies interior supply chains.

Business rules markup language (BRML) is an intelligent-agent facilitated technology that could help heterogeneous e-commerce-related applications to exchange “rules.” It is referred to as an “interlingua” technology that was developed by IBM while the company was working on the Business Rules for E-Commerce project. What this has to do with intelligent agents is that bots have been relying on the knowledge interchange format (KIF) to transfer knowledge. BRML is supposed to add “prioritized conflict handling” capability to KIF, which is important for maintaining business rules and when transferring information between systems such as those between different internal supply chain partners.

West and Hess (2002) say that software agents (intelligent agents) should be employed to help users with interactivity and difficult spatially relevant jobs. This also pertains to the user friendly, or procedural aspect of GIS knowledge management, even when the procedures to use the specific GIS package are contained within the instruction manual that is geared for GIS programmers and analysts (West and Hess, 2002).

Intelligent agents can facilitate comparison shopping. Kim and Eom (2002) suggest using intelligent agents to not only allow customers to compare product prices, but also to compare products on multi attributes. For online grocers the various attributes could be product freshness, nutritional information, average delivery time per product, and more. The article states that just as important as allowing your customers to do comparison shopping through agents, is the need to not block competitors’ intelligent agents from entering your site to perform comparisons (Kim and Eom, 2002). This is because if a

store does not appear on an online shopper's online comparison list because that store blocked the incoming agents, that shopper might think that particular store does not carry the item that the shopper is looking for.

Intelligent agents are discussed by Tsou and Battenfield (2002) in their literature about GIServices (GIServices are explained below). Agents can be used on a distributed GIS-enabled computer architecture to find and bind spatial data objects across networks. According to these authors, three intelligent agents perform the distributed GIS system find and bind functionality. They are filter agents, interpreter agents, and decision agents. Collectively, these agents find the requested information, filter out unnecessary data, bridge heterogeneous data environments, and autonomously make decisions such as what server to use to send the requested information to the GIS user. Sometimes spatially enabled artificial agents communicate between themselves using the knowledge query and manipulation language (KQML) (Tsou and Battenfield, 2002). Online grocers with more than one distribution center should consider using this type of technology when adopting GIS-enabled delivery solutions.

Although not strictly necessary for the development of delivery zones, swarm intelligence and complexity are scientific fields that have recently come to the fore in some business strategies. A primary reason that this literature is reviewed is because of the intuitive value that these two concepts can have for the construction of delivery regions in a geographic enterprise optimization system (GEOS).

Literature exists that explains the combination of GIS with "swarm intelligence." A project undertaken by the Department of Geography at Southwest Texas State University

incorporates swarm intelligence with GIS to “study and simulate” various entities in supply chain situations (Zhang, undated).

Swarm intelligence can loosely be defined as a neural network of interacting intelligent agents. Whereas a neural network is commonly a closed network, meaning that inputs and outputs are controlled, swarm intelligence can denote the utilization of intelligent agents moving over disparate systems to detect unforeseen patterns (Payman, undated).

Eric Bonebau is one of the pioneers of applying the concept of swarm intelligence to managing business. He is a coauthor of “Swarm Intelligence: From Natural to Artificial Systems, 1999. According to Fredman, ants set up supply chains to accomplish sophisticated tasks, and the emulation of these processes can help companies deal with complex environments. Her literature explains how logistics is a “natural application of these ant-foraging algorithms.”

Conventional supply chains use more or less centralized methods to forecast demand and fulfillment. According to Roy (1998) centralized planning methods can be disrupted by fluctuations in customer demand. More suitable than centralized planning is conceptualizing the supply chain as a supply web, and incorporating swarm intelligence to traverse the web to better calculate and compensate for demand fluctuations (Roy, 1998). One particular statement by Roy (1998) summarizes a main point of my emphasis on profitability thresholds as driving forces behind the shape of delivery zones. This is “any changes in customer demand...can easily affect how feasible or profitable a given plan may be. These unplanned events will always happen, so it is desirable to create a management system that adjusts to them more gracefully” (Roy, 1998). He uses a vehicle

analogy is used to demonstrate this point. Simply stated, instead of having a “centralized” vehicle and adding parts to it, it can be better to conceptualize having thousands of parts that “flock together” to become a vehicle (Roy, 1998). This concept may be very useful when parceling groceries together for individual orders or routes.

According to Roy (1998), if swarming intelligent agents learn about region-specific pricing dynamics they could help “develop new strategies to take advantage of changing market conditions. Roy (1998) says that each swarming agent can individually generate “internal make” suborders. It is not difficult to visualize how this could facilitate packaging and shipping of groceries purchased online. After some time the agents can attain the ability to “create new forecasting techniques and learn which of the techniques are most accurate” (Roy, 1998). When it comes down to it, accurate forecasting is the linchpin that online grocers depend on. At an extreme, if forecasting could be 100% accurate, no wasted efforts in packing or shipping would be incurred, which would of course result in significant competitive advantage.

Enterprise Resource Planning (ERP) is an established technological methodology that is used to facilitate and assimilate information flows between and within departments in an enterprise. ERP uses centralized databases, common user interfaces, and sophisticated middleware to optimize the information flow within a company, or between supply chain members, thereby increasing the accuracy and timeliness of inter-corporate and intra-corporate decision making. ERP vendors are increasingly incorporating forecasting functionality into integrated applications. J.D. Edwards sells the Demand Planning 4.0 collaborative application module to enable partners to better make forecasts throughout the supply chain (Ferguson, 2002a). According to Ferguson, the software uses

“market intelligence” and demand information to predict product demand. Although the article does not state from where the market intelligence originates, it would be desirable if the information comes from current industry-specific marketing research data. Demand Planning 4.0 also accounts for holidays and promotions when forecasting demand. A key word in the description of this supply-chain centered product is “collaboration.” This effort by J.D. Edwards shows that there is importance in having forecasting information readily available when collaborating throughout the supply chain. More collaboration-related literature is reviewed below.

Southwest Airlines is saving \$10,000,000 annually by using swarm intelligence to help route cargo (Fredman, 2003). Problems were arising from ground crews using their judgment about what flights they should forward luggage and other cargo to. Naturally, the cargo handlers would wait for the next flight that had space in the cargo hold that was going in the same direction as the luggage. This procedure, however, was not optimal, as discovered after using swarm intelligence. This technology revealed that many times it is better to leave the luggage on a plane than to use ground crew manpower to change the luggage in mid route. Southwest’s freight transfer rates have reduced by up to 80%, the necessity for storage facilities has been decreased, and payroll has been reduced because of the decrease in necessary manpower (Fredman, 2003). Other noteworthy companies that are using swarm intelligence-related solutions effectively are Unilever and Capital One. As stated by Fredman (2003), the use of swarm intelligence in complex organizations helps these organizations harness their tacit knowledge. Tacit knowledge is knowledge that is difficult to codify in databases, but has high value because of the exclusivity it has to the company that is using it. In other words, tacit knowledge can give

a company its competitive edge. This is precisely what is needed for businesses to succeed in the low profitability margin online grocery industry.

As expected, “swarming” intelligent agents perform tasks that mimic life forms such as ants, bees, or birds which exhibit swarming behavior (Resnick, 1998). Foraging for data (like ants foraging for food) is the primary task of swarming agents. It is not hard to imagine how swarming intelligence could help create delivery zones. Swarming agents could collect data from tens of thousands of entities in delivery regions such as PDAs, trucks, databases, and directories, and present this information in real time to strategic decision support systems.

Deborah Gordon (2002) published an interesting article about task allocation within an ant colony. Amazingly, although essential tasks such as caring for the young ants, nest construction and maintenance, and foraging are accomplished in a very efficient manner, nothing is in charge of “managing” these operations (Gordon, 2002). According to the literature, it seems like some of the task allocation within a nest depends upon the number of ants that are already involved in performing that particular task. For example, if an ant leaves the nest to forage for food and does not return, no other ants leave the nest that day. But if it does return, successively increasing amounts of ants will leave to find food and perform other tasks like carrying any dead ants back to the nest.

Communication between ants is performed when the insects touch their antenna. Also, ants emit an odor that is specific to the task that they are performing. The ants do not tell the other ants what to do; instead it is the interaction pattern that determines the probability that an ant will perform a job (Gordon, 2002). Another relevant fact is that because ants live only a year, there is no handing down of knowledge from one

generation to another. The work that gets done is due to indigenous knowledge that the nest collectively possesses.

Gordon's (2002) research alludes to ongoing work that uses intelligent agents to simulate the collective jobs that are performed by social insects such as ants and wasps. It should be relatively easy to imagine the benefit that the incorporation of these types of agents into an information system that creates delivery zones. The potential decision-making accuracy, resilience, forecasting ability, and longevity of such a system are some of the benefits that make the utilization of swarm intelligence a technology that is worthwhile of study by online grocers.

A relevant project undertaken at the department of Zoology at Michigan State University is the Multi-Agent Based Economic Landscape (MABEL). The project simulates the group dynamics of individuals in institutional and organizational environments by using swarm intelligence with GIS (Mabel, 2002). Although the incorporation of intelligent agents into GIS-augmented online grocery delivery routing applications has yet to develop, many of the technological tools already exist to make this combination possible.

Ants and bees have been studied to determine how these insects efficiently work together to accomplish sophisticated tasks such as procuring nutrition or building tectonically durable nests and hives. These types of studies are not only the underpinnings of swarm intelligence theories and practices, but also integral aspects of a field called complexity science.

Van Uden et al. (2001) call complexity science a body of knowledge that is "not trivial" for business, and the "contender for the top spot in the next era of management

science.” Carol Kennedy (2000) says that complexity science has “exciting possibilities” for various fields including logistics. The Southwest Airlines example above was an instance of a company using artificial intelligence to solve a “chaotic” situation. Complexity science recognizes that systems, whether those systems are biological, technical, or organizational, exist in a chaotic world where forces are constantly impinging upon the system. Regions, such as delivery regions serviced by online grocers, can clearly be considered examples of systems existing in a chaotic and complex environment. Whenever online orders are coming into the grocer’s system, the regions that need delivery should change shape or composition. Various complexity issues are inherent when considering the delivery, not least of which is the profitability threshold that encompasses myriad variables such as packing time, crime rate along the route, fuel costs, driver familiarity with the area, customer(s) lifetime value, competitive pricing, traffic en route, position of other delivery drivers, customer payment history and payment method, customer profile, and much more. The boundaries of the region are a constantly changing factor because the shape and geographic area of the region’s boundaries can allow, or disallow the region to meet a profitability threshold.

Many properties make a system complex, such as “incompressibility” which is the inability to explain a system in a level that is less complex than the complexity level of the system itself, without losing some of the explanatory aspects of the system. Another notion that is perhaps more relevant to online grocery delivery methods is that a complex system is both deterministically chaotic and anti-chaotic. Deterministically chaotic means being “incredibly sensitive to small disturbances,” and anti-chaotic means being “incredibly insensitive to large disturbances” (Van Uden et al., 2001). It is probably best

for a delivery zone delineation system to be resilient enough to withstand large, unprecedented spikes in orders, while being selectively reactionary to small patterns or states that could make a region profitable or not.

Van Uden et al. (2001) sum up complexity science by saying that it is the body of knowledge that claims that “everything is connected to everything else.” This author’s literature also tells how unwise it is to concentrate on select parts of a system while ignoring the interactions between these parts. If we consider delivery zones as parts of a logistics system, we might find that interactions between these zones are important in determining if the zones should be combined into one deliver zone to meet the profitability threshold, or remain separated.

Complexity science tells us that permanent boundaries never exist (Van Uden et al., 2001). Here again is an argument in favor of changing the boundaries of delivery zones in real time, depending on the overall logistical, operational, and profit “habitat” at hand. “In complexity science, all boundaries are emergent and temporary” (Van Uden et al., 2001).

Another complexity science maxim that should be followed by online grocer delivery zones is the property of self organization, which is synonymous with anti-chaos. As was explained in the section about swarming insects, complex systems have the trait that they can self organize. Concisely stated, when there are a large amount of elements in a large state space, when the conditions are random, these elements “tend to converge into small areas of this space” (Van Uden et al., 2001). The delivery zones should do exactly this. Instead of considering each and every customer as an individual profit creating entity, the system should converge the customers into profitability zones,

regardless of the geographic proximity of the customers with each other and with the store (up to a certain range).

Interestingly enough, this literature says that a trait of self-organization is that if the starting conditions are similar, “a quantitatively similar pattern will always emerge” (Van Uden et al., 2001). This can be somewhat reassuring for online grocers because there will of course be times when a certain proportion of the deliveries will be similar to previous deliveries. This phenomenon should significantly aid in forecasting and pre-packing the groceries.

Stephan Toffler’s book “Adaptive Corporation” is based on many complexity science maxims. He advises the usage of “complex adaptive systems” to cope with the “unpredictability of the modern marketplace” (Lloyd, 2000). Similar to the self-organizing nature of complex systems, Toffler’s “Sense-and-Respond” system allows the realization of benefits such as mass customization and the ability to capitalize upon wild marketplace swings. This book shows the growing awareness of the viability of running organizations as complex systems, instead of operating the organizations hierarchically. The ability to mass customize can be very important for online grocers, especially if we consider packaging as an operational entity that also can be mass customized – which indeed it is because the contents of each package is different than each other package. Therefore, the concepts offered in Toffler’s book can apply to online grocers. Both the meaning of “complexity science” and “complex” can vary depending on who is defining the term(s) (Van Uden et al., 2001). Christoph Adamnil (2002) said, “Nobody knows precisely what is meant by the word ‘complexity.’” John Casti (2001) attempts to clarify what the meaning of complex is. By using the examples of infinitely continuing repeating

decimals as opposed to finite decimals, he says that of course the infinite non-repeating decimals are more complex. He goes on to say that randomness is also measured by degrees, while Adamil (2002) asserts that randomness is the opposite of periodical occurrences. The relevance of this literature is that an organization might want to determine the degree of complexity or randomness of occurrences in an environment before deciding on what type of system to implement. If one agrees with Adamil's (2002) assertion that "randomness does not give rise to organisms," then before a company establishes a system to cope with complexity, the randomness of the environment should be determined in order to predict if the system will be viable – that is, if any type of analogy between an information system and an organism exists. Casti gives a general outline about how to determine complexity and randomness in various environments. Adamil (2002) views complexity as the amount of information that an organism stores about its environment.

Global companies are beginning to become aware of the value of complexity science in their business operations. General Motors, Capital One, and Ford are three such companies (Wujciak, 2003). Perhaps the example most germane to this dissertation is that of Ford. Ford allowed a large array of automobile configurations to be ordered by distributors, which created difficult to manage manufacturing schedules and inaccurate demand forecasts. Ford solved the configuration problem by using methods to reduce complexity.

One possibly useful way of thinking about "populating" a routing information system that creates delivery zones on the fly is a concept offered by Adamil (2002). He says that entropy is "potential knowledge" and that "sequence entropy" is a length of a

tape, and the marks on the tape is the information. Measurement, which in the case of online grocers would be the geographic measurements of the delivery zones, populates the tape. In other words, the geographic measurements of the delivery zones turn the online grocer's entropy into information. Most relevantly, Adamil (2002) states, "the information-filled tape allows you to make predictions about the state of the system that the sequence is information about." In this case the state would be the state of online orders at any particular time, and the predictions would be forecasts of those orders. Intuitively, Adamil (2002) says that a "complexity catastrophe" is a rapidly changing environment. We could view all of the above-stated online grocer failures as resulting from complexity catastrophes. That is if we consider "rapidly changing" to be the state caused by the reception and response to online grocery orders. "If the changes are fast and extreme, not only will the organism be maladapted to this new environment, but also its measurable physical complexity will have decreased commensurately" (Adamil, 2002). This is exactly the situation Webvan found itself in, which of course led to its demise. Therefore, any online grocer that begins a delivery initiative must keep its physical complexity at the utmost minimum that is necessary to fulfill the orders. In other words, multimillion dollar distribution centers, such as those created by Webvan, may not be able to cope with the dynamic environment created by online grocery sales.

### **Online Grocers' Store Locations**

If an online grocer has not yet decided on a site to open the brick-and-click store, the site selection process becomes highly relevant to the businesses' overall strategy. Thrall (2000) asserts that investment in retail location is one of the most important investments a business can make. It can also be the most costly.

Moreover, when one considers that the central store is the epicenter of grocery dispatches, which in turn can contribute to the success or failure of the company because of the high delivery expense and the low profit margin, the site selection process takes on a high magnitude of importance. There is much literature that extols the value of GIS for the retail industry (Grimshaw, 1989; Brown, 2000; Murayama, 2001a; Thrall, 2002a; Hakala, 2003). Although I have found no literature that deals with the use of GIS to create metamorphic delivery regions for online grocers, an abundance of literature exists telling how important GIS is for retail location, delivery, and retail marketing.

Online grocers should use heuristics and techniques that are different from brick and mortar grocers when deciding on the location of their store or distribution center. Although the term “online grocer” is used throughout this dissertation, I suggest that any store selling online should be of the brick-and-click kind. This paper will refer to exclusively online grocers as “pure online grocers.”

Vlachopoulou et al. (2001) enumerate transportation type(s), customer type(s), competitor location(s), and sales levels as some of the factors to consider when choosing a site. The authors recommend using GIS to facilitate the site selection process because of the data and spatial modeling complexity involved. Site selection tools fall in various categories. These categories include analog models, rules of thumb, linear programming, simulation, checklists, gravity models, and linear programming. The “parasitic” approach is mostly used by smaller stores that copy the location decisions of larger retailers (Clarke, 1998).

A broad rule of thumb for online grocers to consider is that goods that are consumed frequently should be distributed from a dense network of locations (Borchert, 1998).

Groceries certainly fit this category, so an online grocer will have to reach a tradeoff in the site selection decision as to have more distribution centers, or stores, and less delivery trucks, or vice versa.

Hernandez et al. (1998) say that because retailers have notoriously been “cavalier” in their approach to store location. Techniques for deciding on the location of a store range from using checklists to sophisticated artificial neural network (ANN) systems. Moreover, some location decisions are in response to location decisions made by the competition. To better strategize retail location, some companies have made semi-autonomous property divisions within the company to manage store location (Hernandez et al., 1998). This means that smaller scale online grocers might have to have some type of “equalizer” because these stores will probably not have the resources to create an entire department devoted to store location or even marketing. Therefore, online grocers could use Hernandez et al.’s (1998) tactical, or local marketing, strata to help compete. Hernandez et al. divides retail location techniques into three strata – strategic, monadic (location mix, such as relocation, re-fascia, and re-merchandising), and tactical (local marketing). One tactical technique that online grocers should be able to efficiently capitalize upon is changing online food prices in response to competitors’ prices. Although brick-and-mortar stores can do this by using the UPC (universal product code) and point-of-sale technology, these stores must rely on periodic advertisement to inform customers of prices. Online grocers who have developed a significant customer base can inform these customers of price changes and coupons by e-mail or as soon as the customers log on to the website.

The maxim that those who do not know history are doomed to repeat it can be applicable to online grocers' site selection strategies. Thrall gives a detailed account of the family "club," showing how the amount of people per dwelling has decreased though time in the United States (Thrall, 2002a). Borchert (1998) supports this fact, while also talking about decreasing birth rates of families. The ramification of these and other demographic trends should be looked at closely by online grocers when deciding where to locate.

Borchert (1998) writes about how lower level stores that were located in city centers are losing their place in established retail hierarchies. It might be possible, however, for online grocers to stem the tide of location displacement by virtue of their delivery strategy. This conjecture remains to be seen, however. Nevertheless, the reinvigoration of many downtown areas, plus the governmental dissuasion of commuters to use cars in downtown areas (primarily in Europe) (Borchert, 1998), can also have an influence on online grocers location strategy.

Clarke (1998) takes the utilization of GIS for retail location planning and divides it into three eras, before approximately 1985, when the technology was not used at all for retail location; from that time to the late 1990's, when GIS gained a foothold in many retail organizations; and the present time when data mining and optimization techniques are used with GIS for retail site selection. He supports his threefold division by showing that retail location has become much more complicated recently, necessitating the usage of artificial intelligence and optimization techniques.

### **Geographic Information Systems for Traffic-Flow Simulation**

Recently efforts have been made to use GIS for simulating traffic flows for various reasons. Considering the great amount of money to be made – or lost – with an online grocery, simulating the time to delivery should be an integral aspect of any strategic plan.

Above, it is described how Punakivi and Saranen (2001) used simulation to determine the delivery times to houses using various criteria such as attended and unattended deliveries. Simulation is also used to determine traffic flows within cities' main commerce areas and between different city centers (Medda, 2003). Traffic simulation can be divided into macroscopic, mesoscopic and microscopic traffic flow simulation. Mesoscopic simulation shows traffic flows at a scale between macroscopic and microscopic. Nokel et al. (2002) have published research about mesoscopic traffic simulation, while Wahle, Chrobok, Pottmeier, and Schreckenberg researched microscopic traffic flow simulation. The research about mesoscopic traffic simulation states that there are many times when the area simulated must be wide enough to be considered macroscopic, but the finer level of roadway detail necessitates a granularity that the authors classify as mesoscopic (Nokel et al., 2002). On the other hand, Wahle et al. (2002) contend that because of the increasing processing power of computers, microscopic traffic simulation is becoming more feasible. The article also says that microscopic traffic simulation is valuable as a transportation planning tool – which helps vehicles navigate the roadway easier.

If a comprehensive grocery delivery plan is to be implemented, simulation using all three scopes of simulation (macro-, meso-, and microscopic) should be considered. Wahle et al. (2002) say that the output, such as travel times, from traffic simulation

systems can be used as input for other intelligent systems. This is precisely what is necessary for a dynamic (real time) grocery delivery schedule information system. The system tested by Wahle et al. (2002) supposedly functions in real time.

Simulation can be used to overcome the current analytical and dynamic modeling inadequacies of GIS applications (Wu, 1999). He recognizes the importance of modeling space-time (spatiotemporal) processes through simulation with GIS, and is supported by literature by Bernard and Kruger (2000). Integration of GIS with spatiotemporal models will allow the “forecasting of space-time patterns in a reasonable, repeatable and consistent way,” precisely what would be required of an application that shows delivery trucks’ performance based on profitability thresholds. While noting that GIS-based simulation is quite complex, Wu (1999) says that three contributions can be made to decision makers by this type of simulation – description, prediction, and prescription. Relating to the macro, meso, and microscopic simulation scopes stated by the authors mentioned above, Wu says that GIS-enabled simulation may reveal relationships between micro and macroscopic behaviors. As applied to grocery delivery, the profitability ramifications related to small deviations in order times might not be discernable in a microscopic simulation, but might be noticeable if the simulation was run on a macroscopic scale. As stated by Wu (1999), the “purpose of simulation is to see how a global structure is evolving from uncoordinated individual behaviors.”

Another benefit of GIS-enabled simulation noted by Wu is that the simulation results can be stored in GIS “scenario libraries” for use in later simulations (Wu, 1999). Bernard et al. discuss the integration of GIS with simulation in some detail. The difference between coupling and integration of GIS applications is explained. Coupling is

transferring data between two GIS, while integration is a “monolithic” model where GIS and simulation tools are implemented on top of a common data and method base (Bernard, 2000). The literature goes on to explain common ground between initiatives undertaken by both the OpenGIS Consortium (OGC) and the Simulation Interoperability Standards Organization (SISO). The OGC’s mission is to facilitate the worldwide proliferation of “geoinformation services.” This is to be accomplished in part by the utilization of two models and a specific architecture, called the Open Geodata Model, the Information Community Model, and the Service Architecture. Much of this initiative is fashioned after the web services paradigm. Of similar importance is the High Level Architecture which was developed by the US Department of Defense, and is supposed to be a standard for interoperable simulation components (Bernard, 2000). According to this literature, these initiatives are necessary because there is a “gap between the offered interfaces and services in the GIS area and the requirements of the simulation area.”

The integration of simulation and GIS can be highly relevant for online grocers who deliver. This integration should allow the use of “what if” analyses to ascertain if delivery regions will meet their profitability threshold or not, which, in turn, will allow managers to better decide when to pre-pack the groceries that have the most probability of being purchased by customers in those regions.

### **Geographic Information Systems for Vehicle Routing and Logistics**

Pain Stubing of Ernst and Young said, “Execution is the most important thing for any retailer” (Reardon, 2000). This can not be overstated when considering online retailer delivery dispatches. GIS, and the role the technology plays in routing, can help online grocers dispatch delivery trucks in the most cost-effective manner.

Closely related to traffic simulations are routing scenarios. There are significant amounts of literature that pertains to the role GIS plays in vehicle routing that can apply to online grocery delivery. Sometimes the GIS can be a component in a spatial decision support system that helps determine the best routes.

Campbell et al. (2001) tell how GIS has helped create new logistical solutions. Their paper talks about a hybrid distance approximation solution to assign routes to snow removal trucks in Montreal. Their hybrid model strives to “combine accuracy of shortest paths ... with the simplicity of approximations.” One aspect tying this research to my dissertation is that the shortest path algorithm alone is perhaps insufficient to determine the best route for delivering groceries. There are other factors that might make a longer-distance path preferable. Essentially, these authors’ hybrid method speeds up the routing process by creating a reduced road network that eliminates superfluous roads. According to the authors, the calculation of routes in very large networks can be cost and time prohibitive (Campbell et al., 2001). A problem with many routing tools is that they view the network and traffic costs as “static” entities, or entities that have attained an “equilibrium” state (Wu, 2001). This is clearly unacceptable for fast changing online grocery delivery schedules. The article reinforces this idea by saying “... a static model of congestion is an oxymoron.” The need for forecasting traffic flows and congestion is addressed in the article. The acronym GIS dynamic traffic assignment (GIS-DTA) is coined by the authors. Aided by a GIS, analysts can change delivery routes according to changes in predicted traffic flows. This simulation was performed using Arc/Info GIS. The importance of coordinating delivery schedules with traffic congestion is underscored

by Browne as he says that delivery reliability decreases as congestion increases (Browne, 1993).

A notable amount of recent literature exists about using simulation in conjunction with spatial decision support systems (SDSS) to solve the vehicle routing problem.

While explaining their Hierarchical Path View Routing (HPVR) model, Huang breaks down vehicle routing systems into two broad types. One is where individual vehicles perform their own routing calculations using CD ROM based maps and on-board computers. The other method uses a centralized path (route) discovery model. The centralized path discovery model was demonstrated by Huang (1997) to be less expensive to implement

The HPVR model is relevant to this dissertation. The model uses only a subset of all the roads possible to suggest a route for a vehicle. They call this method “fragmentation” of arteries. The fragments are classified by road type (highway, side road, etc). This method makes routing computational costs cheaper because not all the roads are used to calculate any particular path from origin to destination. Because of constantly changing road conditions, the status of routes must be recalculated frequently. If HPVR is used, this frequent recalculation of routes can be performed more quickly because fewer roads are used within each hierarchy.

It is worth mentioning here that the hierarchical set that includes highways would be used to calculate paths between regions, which may not be necessary for local grocery deliveries. However, this model has merit because if it is employed by local grocers, unnecessary or superfluous roads may be omitted from local route calculations, thereby speeding up the route-optimization process. Alternately, if the online grocer wishes to

branch out (for example, on weekends) to other customer regions, it could incorporate the main artery hierarchy into the analysis. Also, although I don't propose using a hierarchical method per se to form delivery routes, the hierarchical segregation of roads for logistics and transportation planning has intriguing potential to be used for further grocery delivery route optimization efforts.

GIS can also assist with determining accessibility measures for roads depicted with ITS (intelligent transportation systems). Miller et al. have developed a method of ranking the accessibility of arteries using ArcInfo (Miller, 2000b). Their space-time accessibility model (STAM) calculates the accessibility of nodes in a network based upon drivers' activity schedules. Activity schedules are essentially the times that a specific set of users will use the roads. Accessibility to roads will be greater or less depending upon the time of day. Based upon "travel diaries," drivers' activity schedules are divided into mandatory and discretionary travel times. A similar concept might be used to group online grocery customers into mandatory or discretionary delivery time windows.

Another consideration online grocers might have when developing a logistics strategy is the type of traffic jam that occurs during a certain time of day. Mahnke and Kaupuzs (2001) classify traffic flow into three "regimes." The first is a free flow of small densities of vehicles, which is obviously the preferable time to embark on a delivery route. Next is the "coexisting phase," where traffic jam clusters coexist within free flowing traffic. And the "viscous overcrowded situation," where a high density of cars move at low velocities." These broad classifications could be assigned as variables to the delivery zones to better ascertain if the groceries can be delivered on time. Quite possibly, for example, easternmost delivery zones could be experiencing the first category, while

northwest sections of town may be undergoing the viscous overcrowding condition. With close inspection, it could be discovered that this pattern repeats itself daily. This information should help to enable the scheduling of grocery deliveries with close regard to factors such as congestion patterns.

An inseparable aspect of online grocers' delivery solutions should be the incorporation of GIS into their logistic plans. The entire concept of delivery zones is merely a hollow conception if not executed with a GIS.

A company called IVU Traffic Technologies uses GIS as an integral part of its e-logistics solution (IVU, 2000). This company shows foresight by creating a solution that allows visualization of logistical spatial information to allow informed management decisions. The company asserts that GIS functionality is important for e-logistics solutions because of the importance of location visualization for management decisions. IVU claims, as this paper also asserts, that data visualization, as facilitated by GIS, is especially important for e-businesses that utilize e-logistics solutions. An example of advances made in the GIS visualization field is 3D Analyst. This software application is an Environmental Science Research Institute (ESRI) product that allows realistic animations such being able to "fly through" a region (Thrall, 2002b).

A Korean governmental organization that incorporates GIS into an e-logistics solution is the Electronics and Telecommunications Research Institute (ETRI) which develops GIS / e-logistics postal solutions in their Postal Technology Research Center (Electronics and Telecommunications Research Institute, 2003).

Kipling Holding AB, a German mobile internet technology company also develops e-logistics solutions using GIS. Kipling's niche is the utilization of global systems for

mobile communication (GSM) in their e-logistic solutions. GSM is a prominent technology used for second and 2.5 generation wireless telecommunication services (GEO Community, 2001).

Global systems for mobile communications is showing itself to be a valuable technology in the advancement of e-logistics solutions as evinced by an Indian e-logistics solution provider called, most appropriately, e-Logistics Ltd. According to the owner of e-Logistics Ltd., Mr. V. Sanjeevi, the usage of GPS to monitor trucks is more expensive than using GSM in the e-Logistics solutions (GIS Development, 2001). Sanjeevi also asserts that en-route delay of delivery trucks can be reduced significantly if e-logistics solutions are utilized.

According to IVU Traffic Technologies, “about 80% of all data in a company is location driven” (IVU Traffic Technologies, 2001). The company’s FilialWeb technology enables the selective presentation of spatial information. The word selective is important here because even if companies are able to garner and store real-time spatial information, it is another matter to be able to present it selectively to the operational employees that must make a decision about whether a grocery delivery route is profitable or not.

### **Networks**

LeHeron et al. (2001) explain how supply chains should be networks of tacit and codified knowledge; and that within the last decade there has been a large-scale change in the networks of food consumption. If localized food consumption, especially the consumption that is fulfilled through online grocers, is thought about as being fulfilled through a network of supply chain knowledge, then more innovative models of delivery may be contrived. Using this mode of thought, online grocers might be able to devise

ways of having their suppliers coordinate with the delivery drivers to possibly deliver more bulky items to the drivers as they are en route to or from the customer premises.

According to Balakrishnan et al. (2000), there has been “increasing emphasis in recent years on customer orientation – providing the right product at the right price, time, and place.” And this emphasis has “propagated up the supply chain.”

Industrial networks have been defined as the “spatial pattern of sales linkages” (Benenson, 1998). According to this literature, dense and complicated networks can exist even when small sets of linkages (such as those established by small to medium sized online grocers with their suppliers and customers) exist. These types of networks are not unlike matrices, where the dimensions are equal to the number of interplaying objects.

Benenson et al.’s (1998) comparison of networks to multidimensional matrices lends itself to the thought that some problems encountered by online grocers can possibly be solved by viewing these problems with the assistance of multidimensional databases and multidimensional visualization methods such as virtual reality. These thoughts should be discussed in further research about online grocery delivery solutions. Indeed, albeit in an abstract sense, Benenson et al. (1998) talk about discovering “visually meaningful patterns” in multidimensional information about business networks. They give an example of sales patterns that, they say, could be too complicated to interpret by visual means if depicted on a one or two dimensional map. Moreover, this research cautions to be aware of sub-networks that can exist within networks.

More in line with the intelligent transportation definition of networks, Zhou et al. (2000) talks about modeling networks with objects. Under this model, objects that embody both spatial and thematic information are used to show spatial entities on the GIS.

This literature says that most GIS transportation (GIS-T) applications use a feature-based model to show roads and other pertinent entities. Features are like classes in object-oriented programming and modeling. Therefore, GIS-T applications should go beyond strictly representing features, and use the objects that result from the features. This is similar to the widely accepted object oriented modeling and programming paradigm. By using this object oriented approach, transportation networks can be more “holistically” depicted because each entity such as roads, points, intersections, etc, can be objects that contain the data and functions that work upon the data (Zhou et al., 2000).

Whereas Zhou et al. (2000) recommend the use of “virtual networks” to better depict multi-modal traffic network analyses, virtual multi-mode networks exist by sharing nodes and sharing points in a network that does not necessarily reflect the exact shape of the real multi-mode transportation network. The virtual network abstractly shows the topological relations of the multi-mode network. Evidently, this is a more efficient way of representing multi-mode networks, as the representation of multi-mode networks, but according to Southworth et al. (2000), this is very difficult. Actually, Southworth et al. (2000), while attempting to model intermodal (similar to multi-modal) freight networks discovered that it was easier to model these networks without using GIS! Online grocers may find that a multi-modal delivery system consisting of suppliers trucks, company trucks (or cars), and even possibly bicycles or employees that walk the groceries to the nearest customers. A delivery model where these “walkers” and/or bicycle delivery employees might even meet delivery trucks at predetermined locations to more rapidly deliver to the “last mile” of customers may be depicted using multi-modal classifications. Although I do not necessarily suggest this type of break-of-bulk delivery strategy in this

dissertation, the possibility of modeling multi-mode logistics might make it more feasible to use simulation to better ascertain the cost effectiveness of such last mile break-of-bulk points.

Southworth et al. (2000) claim that because most GIS packages depict networks geometrically, the use of these packages to show multi-modal logistics models is practically useless. This literature says logical intermodal route representations are more appropriate.

### **Data Visualization and Data Representation**

A scientific discipline exists called “visualization in scientific computing” that contains collections of methods that are used to perform high-definition simulation (Bernard, 1998). The existence of this discipline demonstrates the current emphasis on the importance of data visualization. Gahegan (2000) restates the definition of visualization as “the process of creating and viewing graphical images of data...with the aim of increasing human understanding.” He also lists visualization as an important means to achieve collaboration by experts (Gahegan, 2000). Spatial data visualization, especially when adopted by companies that use integrally spatial strategies, such as routing and delivering groceries, should put significant emphasis on adopting visualization technologies to make operational, managerial, and strategic decisions.

The value of clear inter- and intra-corporate visibility is articulated well by John Fontana (2002). He said, “Companies must learn to read their supply chain’s performance...as a gauge of the health of their business.” He goes on to tell how a reflexive phenomenon occurs when something goes wrong in the supply chain (Fontana, 2002). This occurrence, often called the bullwhip effect (Turban, 2002) should be

detected as soon as possible to preempt undesirable ripple effects throughout an online grocer's interior supply chain. Some undesirable outcomes from the bullwhip effect could be overstocking or stock-outs in peak periods. The bullwhip effect can cause operations to stock unnecessary inventory to hedge against unforeseen online spikes in demand.

Robert Malone (2002), executive editor of *Inbound Logistics* magazine, said, "companies need greater visibility along as much of the supply chain as possible." Clyde Witt (2002) supports the notion of the value of supply chain visibility. His article about Ford's six-sigma quality control program tells how visibility along the supply chain is important in achieving six sigma logistical operations. If a supplier fails to deliver on time, or throughput on the factory floor drops below a certain amount, the proper people can be notified, creating a clear picture of the events that occur throughout the supply chain.

Jan Bowland, managing director of KPMG Consulting, agrees with the notion of overall supply chain visibility as an important aspect of logistics. She asserts that shipment visibility is rapidly gaining recognition as an important priority for shippers, particularly inter-modal carriers (Kuhel, 2002). Bowland adds that the value of supply chain visibility goes further than just the awareness of what product is at what location at what time. Full spatiotemporal knowledge should help to alleviate the necessity for safety stocks which are kept in case of emergencies. This is because emergencies are less likely to occur if full visibility into the supply chain is attained.

Despite the relative awareness of the importance of visibility into supply chain operations, the amount of executives that are actually using sophisticated spatiotemporal

monitoring models or spatiotemporal monitoring technologies is surprisingly low.

According to John Zipperer (2002), less than 10% of senior executives surveyed properly track supply chain performance, less than 7% collect correct or relevant information, and less than one third of the executives track supply chain performance beyond the home corporation.

According to Zipperer (2002), telephones and fax machines are still the preferred method for many buyers to send orders to manufacturers, which creates problems such as unnecessary errors. The article goes on to mention some outstanding problems with supply chain monitoring, while noting that the problem of lack of visibility throughout the chain is the most important one. Because the visualization of the internal supply chain of online grocers is of primary importance to pare unnecessary efforts, the lack of awareness of visualization solutions must be addressed when incorporating a grocery delivery plan.

Cartographic animation is valuable when it results in more intuitive judgments. Using cartographic animation, users can see “geospatial transitions as they happen in time, as opposed to simply viewing the end states” (Ogao, 2002). According to these authors, cartographic animation can allow spatial phenomenon to be viewed holistically instead of disparate “instances of time.” The increase of bandwidth because of optical fiber networks can facilitate the rendition of three-dimensional rendering technologies such as virtual reality markup language across networks (Shiode, 2001).

Goodchild (2002) states that transportation research requires many models but comparatively few types of data. The data that is used, however, is chiefly geographic. Defining the combination of GIS and transportation science as “GIS-T,” Goodchild

(2002) elucidates the three viewpoints of GIS-T, the map view, navigation view, and behavioral view. Bergougnoux (2000) supports this standpoint and adds that these three viewpoints can help researchers gain a perspective on the development of GIS-Transportation (GIS-T) solutions. He also refers to GIS-T as “a significant area for research and development.” Goodchild (2002) uses nodes and links to describe the map view. This is similar to Keenan’s physical links and logical links. But Goodchild (2002) notes some flaws with the link/node view such as features that overshoot or undershoot the endpoints. Also, because streets are one-dimensional lines, information pertaining to the respective sides of the streets is lost. Interoperability between spatial databases is another problem. These undesirables are characteristics of the map view.

The navigation view “requires a massive extension of attributes provided in the map view” (Goodchild, 2000). These attributes include factors that show hindrances to the flow of traffic such as turning restrictions (for example, illegal U turns) and one-way streets. An inhibitor to successful representation of streets in the navigation view is that collecting data about the flow of traffic and representing that data in lane views is more expensive than just showing single line, one dimensional streets.

The behavioral view adds the time dimension and takes into consideration how discrete transport objects such as vehicles, boats, trains or people move on the network. Goodchild (2002) says that all the different methods of representation necessary in the behavioral view are not yet included in any one GIS package. Whether the logistics model used by an online grocer needs the navigation view or the behavioral view can be a topic for further research.

Research performed by Winter (2002) underscores the point made by Goodchild that the representation of turning restrictions are an important aspect of the navigation view. According to Winter (2002), every turn has a cost to it such as time used to decelerate and then accelerate, along with waiting time; and these costs should be incorporated in any representation of a transportation network used for logistical purposes. However, incorporating turn costs in a network is expensive because they greatly increase the data necessary to represent the graph, and makes it necessary to create more sophisticated routing algorithms (Winter, 2002). One particular point made by Winter (2002) could especially apply to online grocers delivery plans. He states that a circular tour is when an entity leaves a point, makes a trip, and then returns to that point. This is of course what the grocery delivery truck will do, so estimating the cost, amount, and location of turns that will facilitate, and not hinder, the delivery truck making a circular tour back to the main distribution center should be important factors in the overall logistical plan for grocery delivery.

Data modeling features of GIS should be improved to allow better user interfaces such as “exploratory” data analyses that allow users to progress through non-predetermined paths (Spaccapietra, 2001). This functionality would obviously be useful for grocery delivery.

West and Hess (2002) explain that metadata pertains to both the technical and business aspects of a business, and that the business metadata is especially useful to the end users. Much of what West and Hess (2002) say about the importance of intelligent agents and metadata for end users is reflected by Tsou and Battenfield (2002) as they discuss both of these aspects in the context of distributed geographic information services.

According to Tsou and Battenfield (2002) two type of metadata are required to implement geographic information services (literature pertaining to GIServices is below) – operation metadata and connectivity metadata. Operation metadata facilitates the representation of cartographic information, such as coordinate projection and spatial footprints, across heterogeneous networks. Data connectivity metadata specifies data connection protocols such as java database connectivity (JDBC) and open database connectivity (ODBC) that are used to access spatial data across the network(s).

According to this literature, the use of both operation and data connectivity metadata enables geographic objects to be “more accessible, self-describing, and self-managing.

Dashboards are tools used to quickly and concisely visualize trends in corporate performance by employees that have responsibility to monitor those trends. Often referred to as digital dashboards (Ricadela, 1999a), these tools send important operational indicators to the computers of corporate decision makers. Some of the uses of dashboards, as stated by Whiting (2002a), are mitigating threats, highlighting business opportunities, and depicting performance figures. The underlying technology used in dashboards are data warehouses that amalgamate information from disparate data stores. According to Whiting, GE is a prominent user of dashboard technology. The company incorporates uses a corporate-wide dashboard called the “cockpit” (Whiting, 2002a).

Dashboards are intra-network or internet-enabled business intelligence tools. A difference between dashboards and portals is that dashboards seem to be more task-exclusive, whereas corporate portals can include links to a diverse amount of information sources. Nevertheless, dashboards are becoming popular and are worthwhile investigating as an integral part of GEOS-enabled online grocer logistic plans. Also, the

term “dashboard” is appealing because it connotes control mechanisms in a functional layout. The incorporation of spatiotemporal “instruments” into dashboards such as the depiction of delivery zones could be useful for online grocer logistics strategies and profit maximization.

PeopleSoft and Microsoft are two companies that have begun developing dashboard solutions for businesses (Ricadela, 1999a; Ewalt, 2002). These applications, often classified as business intelligence solutions, show potential to be incorporated into online grocer logistic plans. According to Ewalt (2002), dashboards can give front-line employees better decision making power. An integral part of a GEOS should be some type of dashboard that shows the color-coded regions to be delivered to changing dynamically. At times, operations managers might have to incorporate their judgment about what route a dispatch should go on, especially if the dashboard-enabled GEOS shows that two routes exist, but only one driver is available at the moment. An instance of managers using their GIS-assisted judgment to dispatch delivery trucks is a reflection of Thrall’s assertion that, “GIS is one part of a larger information technology that may be drawn upon to improve our judgment” (Thrall, 1995b).

Some similarities can exist between dashboards that contain GIS and geographic information portals. Indeed, some literature refers to portals and dashboards synonymously (Ricadela, 1999b). A differentiating factor between the two technologies could be that geographic information portals include smart maps. Many aspects of smart maps are similar to the functions that I said should be contained in GEOS in my geography master’s thesis entitled “The Conceptual Integration of Geographic Information Systems into Enterprise Resource Planning.” Those functions essentially

facilitate the retrieval of information pertinent to an area selected on a map. Called “center pieces of graphical information portals,” smart maps can show information not usually included in a GIS such as real time information and interactive regions. As an example, when a user places a cursor over a region of interest on a smart map, an associated “subject tree” or pop up menu appears, providing the user with choices germane to the region (Peinel and Rose, 2001). If an information source contained in the tree is selected, a file will be downloaded from a web browser. According to Peinel and Rose (2001), geographic information portals can help non-GIS professionals use relevant spatial information because of the intuitive, visual nature of the information retrieval aspects of the information trees. Their literature explains that logistics is an application area where geographic information portals can be utilized. The real-time information depiction qualities of smart maps might be suitable for the representation of online grocer delivery zones.

### **Geographic Data and Surface Representation**

Pienarr and Van Brakel (1999) summarize the value of data contained within GIS by saying, “the value of the GIS is dependent on the quality of the data contained within the system, undoubtedly making it the most important component of a GIS.”

It could be financially prohibitive for online grocers to generate their own data about roads and customer profiles – at least during the first few years of operations. This is why online grocers should be aware of the various types of geographic data available to them. Pienarr (1999) divide online geographic data sources into five categories. They are, educational, commercial, information providers, interactive mapping, and online data searching. Educational resources include universities and other schools; businesses and

organizations sometimes provide GIS data, often on a subscription basis; information providers include online GIS journals. Generator services, map browser services, and real-time maps comprise the interactive mapping geographic data source of data. Online data searching providers can have search capabilities using metadata, and permit transfer of data by FTP (Pienarr and Van Brakel, 1999).

Declarative knowledge exists within metadata. When end users have to choose between hundreds of map themes, declarative knowledge can help with their choices (West, 2002). This could be especially important if the end users are not GIS professionals, which is often the case when the average manager or end user is not trained in cartographic principals, which are necessary to create professional GIS coverages. Literature by Miller underscores this point as he discusses the potential for improved geographic representation in spatial analysis through the use of GIScience (Miller, 2000a). Spaccapietra (2001) says the type of end GIS user is changing. Most end users are not GIS specialists, and GIS has not become interactive enough for inexperienced GIS users to use quickly (Spaccapietra, 2001).

Swink and Speier (1999) also highlight the fact that the effectiveness of SDSS is dependent upon the cartographical representation of the data. Swink and Speier (1999) go on to tell that because of the increasing complexity of business data that must be incorporated into maps (such as the data that pertains to logistics and grocery delivery) the level of cartographic detail increases greatly. Many times it is impossible to show the complete level of detail that is available, so GIS must be used judiciously to show data patterns that help users make better decisions. Essentially, as the number of data points to be considered increases, the complexity of the decision at hand increases Swink and

Speier, 1999). Despite this, Swink and Speier (1999) have discovered that better transportation-related decisions are made when more customer zones are included in the analysis instead of less. Results vary, however, if the decision makers have varying degrees of “spatial orientation skills.”

Also worthy of consideration is literature by Bittner and Frank (1999) who argue that although most of the spatial representations rendered by GIS are currently based upon analytical geometry, other ways of representing geographic space might be considered. Most relevant is their proposition that “constraint-based” GIS representation be considered. They also say that language can be a way to represent formal models on a GIS. This too is noteworthy because the results of the calculations for delivery zones can be expressed in words superimposed upon color-coded zones.

Somewhat supporting Bittner and Frank’s (1999) research is research by Marble (2000) who states that GIS inadequately uses the spatial tools available to it. Calling current GIS-related computational approaches “myopic,” he says that the dimension of time has often been omitted in spatial analyses (Marble, 2000). Granted, since the year 2000, more literature has surfaced that pertains to spatiotemporality; but Bittner predicts that GIS and spatial analysis are on the “brink of a major revolution.” In a sense I agree with him because much of the utilization of GIS to determine optimal (profit maximizing) routes for dynamic online businesses like grocers has not yet begun to be realized. This is an important point that is emphasized in my dissertation. Miller (Miller, 2000a) further expresses the inadequacies of current geographic representation through GIS by saying that the inception and rise of GIScience might herald in a “comprehensive re-examination of geographic representation in spatial analysis” (Miller, 2000b). Much of

his assertions are based upon the premise that because computational power is increasing, so should the power of decision makers who use this spatial information. An example of the utilization of computerization to help make spatial decisions is the SpaceStat and DynESDA extensions for ArcView, which perform sophisticated statistical analyses, and depict those analyses graphically (Anselin, 2000). Anselin's (2000) research also says that much of the spatial analytical capacity of applications, especially if those applications can be employed by mainstream GIS packages such as ArcView, MapInfo, or ArcInfo, will allow non GIS experts to better perform these spatial analyses. If this is true, decision makers in industries such as online grocery will benefit from the increased ability to perform complex statistical spatial calculations to ascertain profitable deliveries and more. Also, possibly as a way to make end users of grocery delivery spatial applications acclimated to these types of applications, the users and decision makers could be trained first on more simplistic location-allocation programs such as NEWLAP, that have intuitive menu-driven interfaces (Lindquist, 2002). Because data (such as the data in relational databases) is tabular, an important aspect of GIS is that it can combine tabular data with cartographic data (on maps). When one considers that much customer transaction data is initially stored in tables, this functionality apparently becomes valuable. The value of GIS is increased further when combined with lifestyle data about customers in retailers' catchment areas. In a United Kingdom survey most respondents preferred the MOSAIC lifestyle database, with ACORN the second-most preferred (O'Malley, 1997). Further, when extensions to GIS networking software, such as those that have location-allocation functions, are implemented, catchment areas can be more accurately determined. Geographic location-allocation software assigns demand areas to

supply centers while simultaneously maximizing supplier coverage and minimizing the travel time for customers (Figueroa, 2000).

O'Malley et al. (1997) state that the most important data for retailers are the data that are generated internally. Online grocers can have one important advantage pertaining to internally generated data, which is the generation of internet-generated data. All data relating to purchases made online can and should be added to corporate databases to allow customer analyses. Moreover, many of these analyses can be performed in real time using procedures like online analytical processing. Whereas brick-and-mortar grocers use analytics (more on analytics-related literature is below) to generate coupons on the back of sales receipts to be used on the next purchase; online grocers can generate incentives such as coupons to be used on the current purchase depending on what is in the customers virtual online shopping cart at the time. O'Malley et al. (1997) support this notion, saying that "the future is likely to see greater use of real-time data for analyzing..."

Geographic data is inherently multidimensional, and recent developments in constraint databases are allowing better representation of multidimensional data. Succinctly stated, constraint databases attempt to show infinite collections of points in a finite number of dimensional spaces (Grumbach, 2001). An example would be to show three-dimensional polygons as conjunctions of linear inequalities. Depending on the stipulated constraints, query languages can perform operations on the points that constitute the polygons.

Assessing the exact extent of catchment areas has always been problematic. The reason for this is that the outer boundaries of geographic "sales cones" have fuzzy

boundaries that can only be estimated (Loffler, 1998). Sales cones are areas that radiate away from the store, with the vertex of the cone representing the store (Christaller, 1933). The outer range represents the farthest point at which a customer will travel to a store or a store can deliver to a customer (King, 1984). This outer range is the boundary of a region, where the geographic extent of the region is dictated by the distance decay influence on the customers of a particular retail store that is located within the region. Thrall (2002b) said, “The rate at which demand declines with distance to the retail center is known as the distance decay of store patronage.”

I claim that the shape of customer sales cones for online grocers will be different than for strict brick-and-mortar grocers at that same location. Further, the sales cones for an exclusively brick-and-mortar grocer will change if that grocer begins an online sales and delivery initiative. Additionally, because of the data gleaned from georeferenced online sales, the boundaries of the sales cones will become less fuzzy. Also, speaking of borders of sales cones, it is relevant to note that a “zone of indifference” exists between market areas where the attraction of neither market area is greater for a particular customer (Akwawua, 2001).

Also, it is important for online grocers to calculate the decrease of the customers’ friction of distance that occurs because of the zero drive times, and how those non-existent customer drive times affect the gravity model as pertaining to the “law of retail trade gravitation,” which is, the ratio of shares of turnover of two shopping centers or central places is proportional to the ratio of their attractiveness and vice versa (Loffler, 1998; Thrall, 2000b).

Customer drive times should not be overlooked when developing an online grocery delivery strategy. This is because brick-and mortar grocers' first criteria used when ascertaining a stores prospective customers' trade areas is the customers' drive times to the store (O'Malley, 1997). Therefore, if, through GIS, an online grocer can discover areas where the residents' drive times to the nearest brick-and-mortar grocer are comparatively high, the online grocer could use this information to cater to those residents because they would benefit most by home-delivered groceries bought online in comparison to people living closer to the store.

Loffler (1998) expects the relative cost of shopping trips to increase in the future because of increased drive times to stores combined with greater fuel consumption. This means that the value of purchasing groceries online should increase proportionately with the increases in fuel prices and fuel consumption. Luoma et al. (1993) supply a somewhat antithetical theory by saying that because of the increasing wealth of the customers, the customers will drive even farther, regardless of the size of a shopping center that he or she is going to (Luoma et al., 1993). Still another perspective is given by Borchert (1998), who says that despite any improved customer spending ability, the amount spent for retail goods increases only marginally. Although all of these postulates may be debatable, online grocers should investigate and test these assumptions in their regions to better decide upon marketing and delivery strategies.

Buor (2002) demonstrates how distance decay is relevant for medical services in Ghana. It should also be mentioned that literature has been published that attempts to refine some aspects of the gravity model. For instance, Hu and Pooler (2002) propose a competing destinations model that tries to remove some bias from distance decay

parameters in conventional gravity models. The underlying proposition in the competing destinations model is that an alternative location can “compensate for the bad features of another alternative”. Said another way, “destinations compete for the attention of decision makers,” (Akwawua, 2001). Luoma et al. (1993) support this by saying that some models do not consider competing destinations that lie within a customers “personal threshold.”

The theory of intervening opportunities takes the competing destinations model a step further. According to this theory, “the number of persons going a given distance is directly proportional to the number of opportunities at that distance and inversely proportional to the number of intervening opportunities” (Akwawua et al., 2001). Akwawua et al. (2001) go on to say that some people use the internet to prioritize their search before embarking on a route. Although there are competing destinations and intervening opportunities within the region(s) that a person is willing to travel, a person will limit the destinations to which he or she will travel to those that are “perceived clearly.” Online grocers should capitalize on this assumption by having their web sites outstanding in clarity and functionality.

Chen and Jiang (2000), while emphasizing the importance of integrating disparate spatial data across networked systems, tell how an “event driven” model of spatiotemporal database changes can be an effective way to utilize spatial decision support systems (SDSS). The idea of using events as the basis for computer applications is not new. Visual basic for applications (VBA) is an event driven programming language. This means that an event, such as a mouse click, pressing of a command button, etc, triggers the underlying code to run. Chen and Jiangs’ (2000) literature, however, is an

attempt to use the event driven model to represent spatiotemporal data. The authors say that representation of events in databases is a “hot research topic,” and “this event-driven approach ...provides a new way for simulating system workflow.” Although their research pertains to events within a land parceling SDSS, it is not difficult to extrapolate from this literature how valuable an event based database schema could be for online grocery delivery businesses. If a sudden or gradual increase or decrease of online purchases occurs within two groups of geographically distinct customers, it would be important to determine the cause(s) of this change in ordering patterns. Possibly, the increase of online orders is occurring because certain sections of two adjacent regions are serviced by two or more delivery trucks on certain days, decreasing delivery times and increasing customer satisfaction. The event here would be the superimposition of parts of two or more delivery drivers’ routes (a union of area). The end “state” of the region served by two routes simultaneously would be increased orders (possibly including new customers). Therefore, the connection between the event and the end state, as shown by the event-driven database schema, could show to management the importance of periodically doubling up drivers in certain areas (possibly in areas of high-value customers). Alternately, the correlation of events and end states, in this scenario, might show management, after a cost / benefit analysis is performed, that the amount of increase in customer orders is not sufficient enough to pay for the added expense of doubling up of delivery trucks for that region or time period. For online grocers interested in possibly initiating an event-driven database schema, Chen and Jiang (2000) list useful operators (in augmentation to conventional SQL operators such as AND, OR, etc). Three of these operators are the sequence operator (;) – showing the sequence of events, the

periodic operator (P) – designating an event that occurs periodically, the FIRST operator – which designates that an event occurred before another event (Chen and Jiang, 2000).

Roddick et al. (2001) address other schema issues while talking about the spatiotemporal receptivity (or non-receptivity) of databases. By using “schema versioning,” temporality can be added to a spatial database. This literature makes a distinction between schema versioning and schema evolution by saying that schema versioning is a special type of schema evolution. Schema evolution is the modification of the database schema without any loss of data, while schema versioning is the ability to query all data within a database “both retrospectively and prospectively.” For dynamic delivery zone related businesses, such as online grocers, knowledge of schema versioning and evolution might be of some value. However, as Roddick et al. (2001) state, schema versioning has not been incorporated well into spatiotemporal databases, but also say, “spatial schema versioning would be a useful adjunct to many systems.”

Spatially extended structured query languages (SQL) that use operators such as overlap, direction, contains, and distance, are better at representing data, rather than analyzing the data (Huang, 1999). Two more recent SQL efforts attempt to allow more spatial analytic capabilities. They are SQL3 MultiMedia Specification (SQL/MM), and Open GIS Simple Features Specification for SQL (OpenGIS SQL). SQL/Temporal is an international standard for spatiotemporal data modeling (Peuquet, 2001). Many of the functions contained in SQL/Spatial are similar to those in ArcView. Some operations are VORONI, CONVEXHULL, DISJOINT, WITHIN, and DIFFERENCE. According to Huang et al., the functions that create new types of spatial features are the most difficult to define in SQL. SQL/Spatial can be run on a client / server architecture, with an

interactive front end for making queries and a SQL/Spatial server on the back end (Huang, 1999).

While considering employing any database schema technique, online grocers should not forget that not all street databases are directly compatible with each other.

Interpretation of features (ontology) and level of detail are two aspects where cartographic data can differ (Noronha, 2000). Objects such as turn lanes and traffic circles might not be represented on all maps. Also, Noronha (2000) says that most databases store addresses as ranges rather than individual address points. This clearly could be a problem for online grocers. Another consideration is that if delivery drivers will be navigating while using mobile cartographic devices (which they should be doing in order to respond in real time to online grocery order changes), is that maps take much longer to download than other types of representations. Bertolotto and Egenhofer (2001) propose a more expeditious way to download maps, which allows initially only a partial representation of the map that is being downloaded. This literature explains the difficulties of segmenting portions of a vector map to be downloaded. These difficulties do not necessarily apply to raster maps. One difficulty is that when maps are overlaid in a GIS, the process of sending those maps over a network is computationally expensive. Map generalization, which is decreasing a vector map's detail, is a "complex and time-consuming process," (Bertolotto and Egenhofer, 2001). Nevertheless, this type of problem must be solved by online grocers who want to send maps in real time over the network to delivery drivers.

Surface representation of elevation also may have relevance to routing solutions. The point at which a delivery zone meets a profitability threshold can be calculated by

incorporating some principles of fluid dynamics that use interpolated depressions and relief of a map using a GIS. Atkinson says that measures of elevation are relatively simple to apply to maps, and that this measurement “is of fundamental importance for a range of applications.” Moreover, supporting the assertion that profitability can more intuitively, and perhaps more accurately, be depicted and calculated over a region is literature by Chang and Harrington (2000) say that profit can form a “landscape.” Their literature goes on to discuss how different degrees of “fitness” can affect the profitability landscape. If Chang and Harrington’s (2000) concept of “consumer preferences” can be considered analogous to changing consumer online grocery purchases, we can see how the spatial representation of profitability might be worthwhile endeavor.

Etzelmuller (2000) discusses different ways of showing changes in surfaces by using grid-based digital elevation models (DEM). By using DEM, it is possible to quantify surfaces to compare the surfaces for aspects such as roughness, changes to the surface(s), and “noisier” or less noisy surfaces (Etzelmuller, 2000). Some of this calculation is performed by assigning wavelengths to surfaces, and having the higher amplitudes representing relief, and wavelength valleys representing depressions. The DEM calculations result in a coefficient that when equal to 1, represents small topographical changes, and 0 or a negative number means larger topographical changes. This type of allocation of coefficients to topography could have relevance to the “terrain” transcended by grocery delivery vehicles. Therefore, this research deserves further consideration when developing logistical applications for businesses.

Additionally, besides just quantifying surfaces in DEM using Etzelmuller’s (2000) wavelength technique, data pertaining to various features can be overlaid on digital

elevation models. This might be useful in a trough and relief method for calculating profitability thresholds.

I propose that “conventional” representation of polygons on GIS are not suitable for many business decisions, such as those decisions that must be made by online grocers about most profitable routes. Cressie et al. (2000) reinforce this idea by stating, “polygons are typically counties, health districts, or states, which are politically chosen entities that often have nothing to do with the etiology of the phenomenon.” In many ways, using predetermined polygons for routing profitability analysis is too constraining, and cannot lead to accurate determinations of the value of any particular route. Also, attributes related to polygons change all the time. Stagnant cartographic polygons may not be able to adequately show these changes. Indeed, Cressie et al. (2000) say that causation of events can be better determined when data relating to polygons are modeled according to time.

The literature pertaining to fuzzy points, fuzzy polygons, and spatial uncertainty is provided because of the possibility of applying these types of uncertainty measurement to online grocery delivery systems.

Besides the actual representation of polygons, the relationship between the polygons and the points (customer nodes, delivery trucks, etc) must be considered. When some sort of non-definitiveness or imprecision exists about the nodes within a polygon we can say that the points exist with some sort of uncertainty (Leung, 1997; Morris, 2003; Robinson, 2003). In essence, fuzzy sets add a dimension to Boolean algebra that proposes every proposition is either true or false. Fuzzy sets add a “middle,” subjective possibility called a membership function (Robinson, 2003). These membership functions can be shown on

an x and y graph as triangular, trapezoidal, or Gaussian. Fuzzy sets can provide an infinite set of values that apply to variables (Morris, 2003). In other words, the degree of membership of a variable to a class is expressed rather than the probability of membership of a variable to a class (Peuquet, 2001). Robinson (2003) predicts that as the sophistication of GIS increases, the need for human input for the definition of the fuzzy set function should decrease.

We could consider grocery orders from customers within a region that come in to the online grocer with no determinable pattern (completely stochastic) as random orders. This could lead to decisions to be made under uncertainty. Some of these decisions would be to have a buffer amount of inventory, or have extra drivers on standby in case forecasted orders actually come in. Decisions made under uncertainty relate to fuzzy set concepts, which have been attempted with GIS (Leung, 1997). A point or polygon represented on a GIS can be considered fuzzy if either object's shape or location is imprecisely recognized. Basically stated, a point or polygon can have degrees of belongingness to sets of properties. The body of literature pertaining to using GIS to make decisions under uncertainty is growing, however, the literature pertaining to allotting degrees of fuzziness to points and polygons is limited. Robinson (Robinson, 2003) stated that although the use of fuzzy sets in GIS has grown in the last decade, commercially available GIS that support fuzzy information processing is rare. The above-cited authors' research can possibly be applied to grocery deliver zones, especially if the shape of those zones are considered random or fuzzy. Moreover, because fuzzy sets allow the meanings of natural sentences (that contain indefinite words like near, where, how, large, and small) to better be projected on a map, the advancement of fuzzy sets in GIS

seems inevitable, and the online grocers that become early adopters of the technology may gain valuable first mover advantage in this highly competitive market.

Cheng et al. (1999) say that most natural phenomena are bounded by fuzzy transition zones. Can the changes in customer catchment region boundaries be considered natural phenomena? If not, Cheng et al.'s (1999) assertion could also apply to "unnatural" phenomena. Nevertheless, since online grocers' delivery areas may change, sometimes hourly, the conception of fuzzy transition zones could apply to these regions. However, it is difficult to measure the changes in transition zones, especially since fuzzy transition zones may overlap in contiguous regions (Cheng et al., 1999). According to these authors, regions change shape during "epochs;" and the changes in the regions are measured by comparing their size at different epochs, during which time they might have shrunk, shifted, or expanded. This is called state transition. Peuquet (2001) supports this view by stating that regional boundaries, along with boundary categories can be fuzzy. This mode of thought can be of use to online grocers who want to calculate to different degrees about if a region is profitable or not before dispatching a truck.

Allan and Lowell (2002) propose another way of dealing with spatial uncertainty by using "abjects." They say that all points, lines, and polygons on a map can belong to several map classes, which denotes that the prominent map class to which these entities belong is not always certain. Polygons whose classes are indeterminate are abjects. Abjects that are surrounded by objects (which definitively belong to a particular class) can, under certain circumstances be joined or merged with the class, thereby becoming part of the object itself (Allan and Lowell, 2002).

Funamoto (2000) endorses the notion of multi-level “clumps” of points that exist within geographic polygons. According to him, geographic clumps develop because of various phenomenon, such as concentrations of cancer victims within a region. Defined, a clump is a cluster of points, with each point having a circle of a certain radius emanating from it. The “clump radius” is the collective radii of the circles. What this research seems to be is another way of depicting geographic concentration, which could be of value to logistic models. Funamoto’s (2000) research is noted here because of the potential of incorporating his theories into online grocery delivery models.

Clumps should not be confused with clusters, however. Clusters are the much-debated macroeconomic theory by Michael Porter about how related businesses “cluster” around each other (Martin, 2003).

When geographic data is represented in layers, as is commonly done by a GIS, the resulting spatial entities (points, lines, and polygons) are quantified to arrive at certain conclusions. Once the data is quantified, it can be studied by order, topology, or algebraic methods (Yongli, 2000). An online grocer might transform visual cartographic information into quantitative information by layering a coverage containing the distance from the nearest distribution center with a coverage containing the amount of purchases per week to derive a new coverage that can tell if closer customers order more often.

One way to show the quantification of map layers is through map algebra, which is a way to sample continuous space, and show those samples on a template that contains rows and columns. Interestingly, algebra, which is most often associated exclusively with numbers, is actually a way to “facilitate integration and cross-fertilization of abstract models,” (Pullar, 2001). In this case, the abstract model is a map.

MapScript implements map algebra using C++ class libraries which include functionality for arithmetic, trigonometric, exponential, and relational operations on templates, where templates refer to arbitrary neighborhoods. Groups of cells within a template are also neighborhoods. According to Pullar (2001), by using the cell / template representation of neighborhood values, a “large class of high level statistical and mathematical operations” can be performed, including time-dependent analyses. This form of modeling can be used to examine changes across space and time. Pullar (2001) says, “travel time is related to the cost, or work effort, to move a certain distance.” My addition to this postulate is that since time essentially equals money, if the work effort results in enough profit, then the cost of the travel will decrease or even become non-frictional. The relationship of map algebra to the method I am suggesting is that instead of conceptualizing neighborhoods using two-dimensional templates, such as those used by map algebra, we can conceptualize the neighborhoods (delivery zones) as three dimensional entities, incorporating the profitability variable (or other variables) as the third dimension. This could be called map calculus, but since the online grocer delivery zones could change, often in real time, fluid dynamics may be the more appropriate way to conceptualize this regional quantification. As mentioned by Bernard and Kruger, adaptive geographic grids can be used to simulate the movement of fluid. Also, if cartographic representations are three dimensional, hydrodynamic movement may be simulated (Bernard, 2000). Therefore, if innovative thinking is used, modeling methods such as map algebra and fluid dynamics may be very important steps for quantifying delivery regions for online grocers. It should be noted, however, that because three-dimensional data is not readily available on the commercial marketplace (Koning and

Bartel, 1998) online grocers might have to pay for expensive data collection if this option is employed. Also, according to Koninger and Bartel (1998), there exists a way to represent solids called constructive solid geometry, which uses Boolean operations to make more complex solid objects from simpler three dimensional objects. Pullar (2001) explains that “mathematical morphology” within map algebra is the theory for analyzing spatial structures. Two morphological operators, dilation and erosion, change the region under study by either increasing or decreasing the size of the region. Also, cells within a neighborhood template can either die, be born, or continue to live, depending on the properties of the nearest cells. It seems feasible that the dilation and erosion operators, or some semblance of them, can be used to create delivery regions.

When incorporating map algebra, or virtually any spatial quantification method, some thought should be given to linear referencing, which can render the necessity of locating points on the earth’s surface unnecessary when performing spatial quantifications (Scarponcini, 2002). This is done by using anchor points, such as benchmarks, which are georeferenced points used as initial reference points. Then, from the anchor points arbitrarily spaced points are placed. The points are one-dimensional entities used to specify locations. Once points are arranged in a route or network topology from an anchor point or between anchor points, a linear data topology exists. One trait inherent in a linear topology is that if an anchor point changes because of, for example, the change in the location of a traffic intersection, the linear topology does not necessarily have to change. The origin of the topology merely begins at a different anchor point. A section bastioned by an anchor point is called an anchor section. Scarponcini (2002) says that anchor sections are more stable than routes because routes become

unusable as the entire linear datum topology changes. This is not the case in linear referenced topologies because in linear referencing, measurements relative to the anchor point(s) are made when depicting the datum topology, as opposed to absolute measurements such as measurements made to place mile markers at permanent intervals from a state or county line, for example. When a route comprised of absolute measurements changes, each measured point on the route must change. This is not so with linear referenced topologies (Scarponcini, 2002).

Just as absolutely measured distances can cause problems when route changes occur, spatial scale poses its own problems when using GIS to decide on best routes, such as delivery routes used by online grocers. Even the definition of “scale” can be ambiguous, meaning both “spatial extent” and “amount of detail” (Atkinson, 2000). An aspect of scale that is important to online grocers is that entities shown at one scale can acquire considerably different relevance when viewed at another scale. As an example, areas not serviced might not be visible when viewed on a GIS in small scale, whereas these areas might become highly noticeable when viewing a subsection of the original area at a larger scale. According to Atkinson, heterogeneity and regularity of cartographic entities can change when the scale is adjusted. The same grocery delivery routes that look elliptical at a small scale might look polygonal at a larger scale. An exception to this phenomenon is fractals. Fractals are patterns that do not significantly deviate when viewed at different scales. Fractal patterns exist in both physical and human geography (Atkinson, 2000).

One way to decide on a scale appropriate for the job at hand, such as viewing the most grocery delivery zones, while seeing the closest points any two delivery trucks are at the same time, is to scale the map down, then scale it up until “robust” parameters are

discovered. Robust parameters are those parameters that are visible and relevant at all scales within the study area. The area studied is also known as the “support” (Atkinson, 2000).

Adjustments in scale can also affect the way spatial dependence between regions is viewed. The fact that households of certain LSPs (lifestyle segmentation profiles) live closely together within a region can be lost if the regions are viewed at too small a scale. Some of this information loss can be mitigated by kriging, or “smoothing” of information from neighboring regions to adjacent regions.

Moreover, because scale can be divided into spatial and temporal realms (Maruca, 2002) the problems associated with scale become that much more complex.

Somewhat related to the above-stated micro-, macro- and meso-scopic traffic flow simulation scales is micro-, macro-, and mesoscale scale representations (Bernard, 1998). Mesoscale representations extend from a few to several hundred kilometers. Microscale and macroscale representations are, of course, respectively less than, or greater than this range.

According to Haining et al. (2000), quantitative measures that are incorporated into GIS packages are not sufficiently inclusive or sophisticated. Nevertheless, it is important that online grocers become aware of some of the existing quantitative functionality. There is no shortage of literature pertaining to this topic, although no writings could be found that are exclusively focused toward online grocer decision-making using GIS-enabled statistical processes. Although considerable breadth could be allotted to this subject, an account of just a few of the more pertinent spatial statistical packages is included in this literature review.

Spatial analysis in a GIS environment (SAGE) is a statistical package that can be integrated with Arc/Info. SAGE works with polygon coverages and includes data management, graphical drawing, querying, and classification tools (Haining et al., 2000). Polygons input into SAGE can be “dissolved” to create coverages for sets of regions. Linear regression, a common statistical method used by geographers and other scientists, is enabled by SAGE. Ordinary linear regression, linear regression with spatially correlated errors, and linear regression with a spatially lagged response variable are the three types of linear regression that can be performed by using SAGE. Dynamic brushing, the operation of quantifying the movement of a shape over a region, is not handled very well by SAGE, however (Haining, 2000).

a spatial data analysis package that can be integrated with ArcView is called S-PLUS. Besides being a quantitative system with more than 2000 functions, S-PLUS is also an object-oriented language. By creating customized ArcView Avenue scripts, users can increase the analytical capabilities of S-PLUS. Data transfer between ArcView and S-PLUS is supposed to be relatively seamless (Bao, 2000). S-PLUS graphs include boxplots, histograms, variograms, and multiple three-dimensional layouts.

### **Geographic Information Systems in Business**

The literature cited leaves little room for doubt that GIS in combination with decision-making tools and artificial intelligence will continue to be useful as a facilitative system to allow optimal decisions in many business settings, including the online grocery business. Business geography and “managerial geography” are gradually being recognized as a means to a competitive edge (Risto, 1998). Dr. Grant Thrall (2000) has recently published an important book about business geography, which gives greater

impetus to the recognition of the field of business geography as a bona fide aspect of geography and an important aspect of business location strategy. Following is a review of other literature that asserts the usefulness of GIS as a managerial tool.

Grimshaw (2001) says that the primary business benefits attained through scheduling and routing systems is gained by linking geographic knowledge about customers to these systems. Although there have been great efforts by small and medium enterprises to integrate corporate-wide data, such as through ERP systems, most businesses have ignored this “key dimension” of data. Businesses concentrate on the “what, how, and why” of strategy but to a much less extent consider the “where” dimension (Heinritz, 1998; Grimshaw, 2001). One reason for this non-integration of geographic data is that smaller businesses, such as many online grocers, do not have the technical or intellectual resources to do this. Despite this, O’Malley et al. (1997) have found that 48% of survey respondents (United Kingdom retailers) develop in-house spatial databases. Yet, these authors have stated that retailers are “data rich...but...information poor” (Hernandez, 1998). Nevertheless, as Grimshaw (2001) says, because “benefits from improved routing and scheduling go hand in hand with benefits from improved customer relations,” the geographic aspect of data should not be overlooked, especially by the online grocery industry, which has low profit margins.

Perhaps one of the most important points Grimshaw (2001) makes is that geographic knowledge about who the most profitable customers are. In order to better calculate the profitability of each delivery route, georeferenced customer profitability variables should be incorporated into the equation. Niraj et al. (2001) bolster the notion of the different value of customers. Their literature also explains that the lifetime value of a customer

should be calculated. Although their research concentrates on the lifetime value of supply chain partners, some of their findings can be applicable to the lifetime value of online grocery customers. One thing they say is that the cost of serving each customer can be different, thereby affecting the lifetime value of the customer (Niraj et al., 2001). This becomes clear in an online grocery delivery context when variables like time to walk to the back door, presence of mean dogs, and high crime neighborhoods are added into the lifetime value calculation for individual customers.

Of the three categories of GIS stated by Brown (2000), the category of GIS as an analytical system best fits the needs of online grocery delivery initiatives. As an analytical system, the use of GIS has various benefits for business decision makers. Hickman goes as far as to say that by converting large amounts of geographic and tabular information into a more useful form, GIS “enhances every aspect of the business” (Hickman, 1999). Most pertinent to this dissertation is the article’s mention of the usefulness of GIS to help track routes in real time.

As “early as” 1989 the value of GIS for business was predicted by some literature. While reinforcing the fact that much industrial data have geographic dimensions, Grimshaw (1989) said that retailers can “revolutionize” their marketing plans by georeferencing customer data. Two of the four factors that he said would influence the adoption of GIS in business are particularly true for the online grocery industry. Those factors are better techniques for handling spatial data, and awareness of the spatial data combined with human skills (Grimshaw, 1989). A main point of this dissertation is that if online grocers handle their spatial data better, thereby resulting in the recognition of

zones that surpass profitability thresholds, even online grocers, with their notoriously thin profit margins, could become successful.

In a later article, Grimshaw (1991) expounds upon his earlier literature and states that GIS should be an integral part of overall corporate information systems and “strongly linked to the business strategy. Indeed, this is the view that online grocers should take when considering GIS as part of their logistical model. He also asserts that GIS should be used as a not only an operational and managerial tool, but also as a strategic tool.

Although there could be debate as to whether he properly classifies the utilization of GIS to facilitate the “delivery of information-based products or services” as a “strategic” entity, as opposed to an operational entity, there is little doubt that GIS should be used to perform the delivery function. Nevertheless, in the same article he asserts that considerable value can be added to corporate information if the geographical aspect of that information is included in the analysis. He expands his evaluation of GIS from mostly a retail-based tool, to a more sweeping analysis of GIS in his more recent publication (Grimshaw, 2002).

While considering GIS as a part of corporate strategy, Grimshaw (1991) says that the use of the technology should be considered an opportunity rather than just a cost. Another way to say this would be that there is an opportunity cost by not using the technology. In the case of online grocers, if GIS technology is not used it may be infeasible to run a successful delivery service, which means that by not using the technology the opportunity to reach the large home grocery market will be lost.

Interestingly literature is still being published that calls GIS “new.” For example David Hakala’s (2003) article entitles “Location: The New Killer App” tells how GIS

when used with databases can be used to make “powerful applications.” This phenomenon of calling two decade-old technology “new” means that there is still significant ignorance within the business community about the potential of GIS as an operational tool (Hakala, 2003). This was not the case with, say, enterprise resource planning (ERP). Is the contrast between the adoption of GIS and ERP due to the possibility that most people are geographically uninformed? Whatever the reason, the stage is set for the adoption of GIS in industries such as online grocers because of the need to view geographic information as a profitability enhancer

Despite the relative slow pace of adoption, GIS is gaining momentum in certain sectors. Murayama (2001b) talks about the adoption of GIS in Japan. Interestingly, he says that most of the editors of GIS-related academic journals are geographers. This in itself shows the as yet lack of intellectual osmosis of GIS into other business-related publications. One might think that integrally spatial fields of business such as logistics or marketing would begin to publish spatially related journals. Evidently, this is not yet occurring, which can also help to explain the lack of geographic solutions employed by businesses in these sectors.

One reason that GIS is gaining popularity in Japan is that data is collected down to very small regions. Also digital maps have been developed at a “rapid pace” since the early 1990s (Murayama, 2001b). Also, according to the same article, point of sale (POS) data is also being accumulated in large quantities in the country. Because of these facts, it seems promising that this research can have strong implications to online grocery delivery services in Japan. A countervailing situation exists, however. This is that Japan

has stricter privacy laws about the usage and dissemination of personal spatial data than the United States does (Murayama, 2001b).

An interesting perspective about the use of GIS in cyberspace has been written by Masanao Takeyama who says that geographers have just begun to study cyberspace, and that the study of geographic “telepresence” holds important meaning for determining “cyberplaces.” Cyberplaces are places of “interactivity between cyberspace and physical places (Takeyama, 2001). Getting a handle on the geography of daily or cyclical cyberplace patterns may help online grocers decide between using home delivery or communal drop boxes. Takeyama (2001) suggests that cyberplaces can cause spatial metamorphism in cities. Online grocers that can detect these new spatial patterns might be better able to cater to the growing market of mobile and stationary internet users.

O’Malley et al. (1997) tells that although store location is the “most critical decision a retailer makes,” the use of GIS to make such a decision by United Kingdom retailers is not as pronounced as it could be. A reason for this is that the technology is not integrated into strategic decision making to any great extent (O’Malley et al., 1997).

Other recent literature exists that supports the premise that GIS and spatially oriented business practices are being adopted more. Lowe (2003) says, “The use of geospatial data is moving from the mapping department in the back office to the existing business practices of the enterprise.” He also talks about supporting technologies that can enable the non-GIS expert to better use spatial business solutions. One such technology is peer-to-peer (P2P) computing which could allow any GIS application on a computer to simultaneously be a client and a server. According to Lowe (2003), “decoupled peer-to-peer spatial environments are removing old barriers that used to exclude non-technical

users.” This means that it is becoming more feasible to initiate solutions such as the delivery route system, which is suggested in this dissertation.

Despite the comparatively slow start GIS has had in taking a foothold in mainstream business applications, the move toward adoption of GIS by science and industry is called a “GIS revolution” (Yano, 2001). This literature says that there have been efforts to increase the value of GIS by making it a geographic knowledge system (GKS). This transformation has sometimes not been successful because some advanced quantitative procedures that can be used with a GIS have not been adopted by mainstream businesses. A factor that might be contributing to this relatively low acceptance of GIS is that United States businesses have been influenced relatively little by academic geography. This is because some of the general public do not fully perceive geography as being a bona fide profession (Yano, 2001).

### **Enabling Geographic Information Systems Technologies**

Because the purpose of this dissertation is to make suggestions that may increase online grocers’ profitability through strategic delivery zones, some review of literature of the enabling GIS technologies will be of value.

For various reasons, a non-centralized GIS information systems platform can better serve end users. One reason is that data that is not centrally located can be more readily accessed by end users who utilize a distributed system. Also, it has been demonstrated that nearest neighbor queries can be efficiently executed in multi-disk and multi processor environments (Papadopoulos, 1997).

By the early 1990’s GIS users were beginning to realize the redundancy behind collecting and creating their own data sets, especially when they could relatively easily

tap into the same type of data that existed across distributed networked environments (Hunter, 2002). Within geography, this type of awareness provided inertia to adopt distributed object and data models such as component object modeling (COM), common object request broker architecture (CORBA), and web services to be used as decentralization facilitators. The Open GIS Consortium attempts to use these technologies by addressing geographic data interoperability problems (Hunter, 2002).

The exploitation of the internet along with the advent of spatial data infrastructures are two developments that have great significance to the utilization of distributed GIS (Abel, 1999). According to these authors, the high capital investments that are required for some sophisticated GIS operations are putting a drag on the proliferation of geographic analysis in business, industry and academia. As a possible response to this, spatial internet marketplaces should allow the geographic distribution of data sets and geographic services by a subscription / request paradigm. In this paradigm, value added resellers would sell the data sets to the customers as soon as it is requested. The literature compares this scheme to pay-per-view television (Abel, 1999). To accomplish this task, federated databases must feed sophisticated distributed processing infrastructures that link together heterogeneous networks. Geographic communities of interest will be formed upon the realization of this type of technological and strategic plan (Abel, 1999). Two important services that should be offered by internet marketplace infrastructures are query services and function services. Query services supply a subset of data to the customer depending on the customer's needs. Function services perform computations on the requested data on software owned and operated by the service provider.

Before continuing with the review of distributed GIS systems literature, a short synopsis of literature related to interoperability is provided next to better become aware of some current technological advances that can facilitate the implementation and deployment of distributed GIS systems.

The term “interoperability” can encompass the use of many different technologies and methods that focus on integration of disparate computer applications. web services, as mentioned above, show great promise to integrate applications. An integral part of web services is extensible markup language (XML). This is a growing standard that is used for creating markup languages and describing data (Deitel, 2003). A main purpose of XML is to keep the data independent of the applications that use it. Taking the utilization of XML one step further is extensible stylesheet language transformation (XSTL). What XSTL does is use XML to basically allow data to be reformatted into different forms depending on the situation. For instance, XSTL can transform a purchase order into a web page or a printable invoice (Dettelback, 2002). This can be a significant step in the ability to visualize data along interior online grocers’ supply chains, especially if documents can efficiently be converted to web pages that are accessible to departments over corporate intranets.

According to Paul Sholz (2002), XML will make data queries possible on a “global scale.” This adds emphasis to the premise that XML can be an important part of interoperability between mobile delivery units and the back end databases.

The term virtual enterprise network (VEN) has recently appeared, giving but another term to the lexicon of terms that relate to inter- and intra- enterprise interoperability. An indicative aspect of VENs is that they concentrate on using inter-enterprise directory

services to facilitate access to intranets and extranets, while making those networks more secure – an important part of any supply chain interoperability solution (Lewis, 2002)

Wang and Nig (2000) say that distributed GIS can fulfill users' needs better than centralized systems. Some reasons are greater system reliability, faster response times, better data sharing capability, and facilitated system growth (Wang and Nig, 2000). Their article shows how CORBA is a technology that allows geographic objects to be stored at remote locations; and how these objects can be called from networked computer nodes. CORBA also helps to solve another problem of distributed geographic data, which is that geographic data structures on two different nodes (computers) can be different. CORBA can mitigate this problem by the ability of the technology to use a common database schema on the distributed system. Moreover, the use of CORBA helps to maintain concurrency control, which is the protection against two stations (people or computers) manipulating the same data at the same time (Wang and Nig, 2000).

What does this mean for online grocery delivery services? For one, delivery people can have access to a richer amount of computer services that originate from various points. These services can include customer relationship management (CRM) capabilities such as cross selling, up selling, or automatic generation of coupons based upon the customer's profile. Because Wang states that greater number of GISs will be networked, this technology can be important for even smaller online grocers. This can also help to ascertain a customer's lifetime value to a company by better showing the customer's transaction patterns and preferences (Niraj, 2001).

A review of literature pertaining to distributed GIS systems would not be complete without some account of literature that pertains to middleware. Middleware is the set of

computational devices – both computers and software components within the applications on those computers – that logically and or physically sit in the “middle” of end user applications and back-end systems such as databases. Middleware technologies are used to integrate computer systems in disparate departments or enterprises into a working functional system.

In an article where the investment firm Morgan Stanley states that one of the firm’s chief priorities is the integration of its applications, two mainstream middleware technologies are compared (DolGicer, 2002). Java servlets and enterprise java beans (EJB) are two middleware technologies that are described in the article. Although the article is quite inclusive in its comparison of these two powerful middleware technologies, one comment is particularly noteworthy. That is, when referring to e-commerce, “there are really only two middleware platforms to choose from – J2EE (java 2 enterprise edition) and .NET (dot net). Enterprise java beans and java servlets are incorporated in J2EE.

In an effort to give order to the different business processes that must be marshaled into the middleware platforms, a technological model called business process management systems (BPMS) takes the end-to-end business processes that exist within an organization or across organizations and establishes a set of rules that the software must abide by to “route” the information through the middleware platform(s). A language called business process modeling language (BPML) is an XML-based language that helps coordinate data within the BPMS (Baker, 2002). Baker, Smith, and Fingar’s (2002) research show how complicated underlying technologies make implementing end-to-end business processes difficult. The technology became a barrier because the technology is a

“manifestation of the complexity and diversity of the systems it (the enterprise) had acquired and developed over the years.” According to the article, BPML can help to model business processes at the business, and not the technical level. This essentially “isolates business design decisions from the complexity of the technical middleware infrastructure...”

Taking the potential of BPML one step further, Renee Ferguson (2002) writes about how the modeling language can play a part in offering business process integration services over the web. Version 1.0 of BPML, which was released in August, 2002, uses a protocol called web services choreography interface (WSOI). The two technologies can help provide software engineers and business analysts with views of how business processes perform in different scenarios. In the article, however, there is some skepticism as to the amount of companies that will actually use BPML and WSOI. Enterprise information integration (EII) is the usage of middleware to give access to multiple disparate databases (April, 2002). A common term for this type of “transparent” data access is “federated databases.” Enterprise information integration performs data coalescing by using metadata repositories from various back-end sources. What this means for visualization within online grocers’ interior supply chains is that any department who have access to another department’s data, through an intranet or portal, for example, can access cross corporate data as easily as if that data was on just one database. This is relevant in companies where terabytes of data might exist across the company on different platforms.

According to the article, Microsoft’s new Yukon SQL Server database and Oracle’s 9i have EII capabilities built in. GIS can be distributed among dispersed users by using

what is called geographic information services (GIServices) (Tsou and Battenfield, 2002). Clearly this is modeled after the web services paradigm. Recent research shows, however, that the provision of GIS as a web service requires different technical obstacles to be overcome. The benefits of GIServices-enabled distributed systems parallel the benefits set forth by Wang for CORBA-enabled distributed systems. A basic tenet of GIServices is that every computer in the distributed system is both a client and server. This architecture helps make the system application independent (meaning the variety of applications that can be used by the system is not constrained by those applications contained by the core system itself). Instead of adopting only CORBA, Tsou and Battenfield (2002) suggest using CORBA in conjunction with the distributed component object model (DCOM) and remote method invocation (RMI).

It is easy to see how GIServices can benefit an online grocer, even if that grocer has only two distribution locations. If there was no interoperability between the respective sites' GIS-enabled routing applications, each distribution center (store or warehouse) might have to deliver to its own geographic region. By enabling the distributed geographic components (see below) to communicate, routes can overlap much like unions in Venn diagrams. This could allow better customer service such a backup deliveries initiated by another distribution center (store) if the other store's delivery truck becomes delayed. Of course, this scenario assumes that different grocery orders are routed to respective stores based upon georeferenced delivery addresses.

Components, as mentioned in the previous paragraph, are "ready-to-run modularized programs that are dynamically loaded into a network-based system to enable GIS functionality" (Tsou and Battenfield, 2002). Essentially, components are similar to

objects in object-oriented programming, but components are more sophisticated, occasionally containing objects. Sometimes components themselves are encased within “containers.” Containers are abstract grouping entities used to better accomplish the abandonment of traditional client / server architectures. This is because each GIS node (computer) is both a client and server in the GIServices paradigm

Componentization of GIS can alleviate the need for batch conversion of data and system import and export difficulties. This is particularly relevant because spatiotemporal data representation necessitates the exchange of great amounts of data between systems (Bernard et al., 1998). Bernard et al. (1998) expound upon the use of component models such as DCOM and CORBA along with application programming interfaces (API) to achieve better interoperability between GIS. Abel also talks about the importance of these component models to enable interoperation within spatial internet marketplaces (Abel, 1999). A problem with distributed GIS is that different applications may use different data dictionaries and taxonomies for the data (Pundt, 2002). For advanced decision-making capabilities and better data accuracy, some online grocers may wish to collect their own data. For example, the online grocer might want to know how long, on average, it takes a particular residence to open the door in order to better determine the route (people who answer the door slower might be delivered to at specific times in the route). Generally speaking, older people might take longer to receive their packages than families with younger children. It is possible to input this data with mobile GIS devices (Pundt, 2002). However, Pundt (2002) says that the issue of semantics – “the meaning of the geographical object rather than the geometrical representation” – should be considered too. Zhou (Zhou et al., 2000) agrees with this but say that semantic

information is difficult to represent on a GIS. If an online grocer operates from a single store, the problem is less troublesome than if various stores must access the same semantically classified data. Pertaining to the time it takes to receive grocery packages, if one store uses the semantic data tags STR, ATR, and FTR, meaning slow to receive, average to receive, and fast to receive, all other stores that use or input data into this distributed system must be aware of and use the same semantic style. Pundt (2002) says that it is more efficient for GIS workers in the field if they know the semantic correctness of the data as they put it in. The input of semantic data by grocery delivery persons can be done by using text box masks, which force the person inputting the data to input it in a certain style such as only numbers within a specific range, or only a specified amount of letters per text box.

Semantic problems can manifest themselves in vague terms such as long, near, old, far, and close; or in statements such as “two roads ‘cross’ each other” (Hunter, 2002). Online grocers should take care to not incorporate these types of ambiguous terms in analyses of delivery routes.

The value of mobile GIS users (grocery deliver persons) inputting data into the system should not be underplayed, especially in the very low profit margin grocery industry. Certain seemingly insignificant information, such as that about streets having inordinate amounts of deep potholes that slow drive times or result in cracked eggs could be easily left out of consideration if drivers are not instructed to record this information while on route. Further, if the drivers are versed on inputting the data into mobile GIS systems, the possibility of incorrect data entering the database could be lessened because the necessity for repeat data entry is lessened. Possibly, an online grocer could make its

own ontological classifications for delivery drivers in order to expedite the data entry process in the field. According to Pundt (2002), ontological (naming and grouping) considerations are very important when using mobile GIS. Grimshaw (2001) also wrote about the value of having delivery drivers add to the corporate spatial knowledge base. He says that information about customers that have narrow drives or poor turning areas can greatly help to improve customer service. This type of information can be used to create impedance tables, or tables that geographically relate to the road network and show hindrances to rapid traversal of the network (Figuerola, 2000). Dunkin Doughnuts is using wireless devices to profile their customers by using gathered spatial information. Handheld devices used by Dunkin Doughnut employees transmit customer survey information to home-office servers (Barnes, 2002).

Another problem with semantics is that data used to visualize geographic entities go through various representations from the time it is captured to the time it is visualized on a GIS. During this process data semantics can be lost and the final geographic representation rendered unclear to the user (Bernard, 1998). Supporting this viewpoint is literature by Frihida et al. (2002) that says geographic “semantic richness” can be lost by database normalization rules.

### **Spatiotemporality**

The amount of literature pertaining to spatiotemporal issues has increased significantly in the last five years. This is probably because of the new emphasis put on spatiotemporal phenomenon (Spaccapietra, 2001). It is only natural that any firm (not just online grocers) that moves goods or people be interested in both the spatial and temporal aspects of the data they use. “Time geography,” which of course encompasses

spatiotemporal concepts, is defined in the Dictionary of Human Geography and includes transport geography, which is a subcategory of human geography that includes household space-time budgets (as mentioned above). According to Lenntorp (1999), during the 1980s more people incorporated time geography into their thoughts, and has thus become more widely accepted by geographers. “Intricate and inseparable processes” can be observed through the usage of time geography (Lanntorp, 1999).

One of the problems with representing discontinuously moving spatiotemporal entities on a GIS is that unless every single latitude and longitude coordinate of the object represented is captured, some “jerkiness” will result because of the lack of smooth arcs that result because of the paucity of points. Saglio and Moreira (2001) attempt to rectify this while demonstrating software benchmarking by using the Oporto simulator. A benchmark is attained by using software to test a system to see if it is functioning adequately.

As opposed to discontinuously moving objects, objects that change (location, direction, size, or shape) continuously are more easily represented because there could be a function of time that exists that when used can more accurately show the change with no discontinuity points. It is important to make the distinction between moving points and moving polygons because moving points are more easily represented (Saglio and Moreira, 2001). Online grocers might be interested in simulating online shapes, especially if they are simulating the increase or decrease in population flow to their marketing catchment areas, for example.

Zhang and Hunter (Zhang and Hunter, 2000) support Saglio and Moreira’s (2001) discontinuity claim by saying that a problem with incorporating temporality into GIS is

that unless the “continuity assumption” is used, it is difficult to accurately show the trajectories of spatially dynamic objects (Zhang and Hunter, 2000). Most relevantly in Zhang and Hunter’s (2000) literature is the assertion that instead of using the z axis for spatial height, as in DTM, the z axis can be conceptualized as a time entity (in which case it would assume the letter t, not z).

Even though geographic data and data representation literature are discussed above, the distinctive nature of spatiotemporal data necessitates allotting some more space in this section for a review of the subject. Despite the literature that is devoted to spatiotemporal issues such as that about spatiotemporal databases, advancements of practical applications in this field have been slow (Tryfona, 1999). Nevertheless, the need for integration of spatial and temporal dimensions is recognized in various current literature such as that written by (Claramunt et al., 2001). Spatiotemporal database functionality was first attempted in the 1980s, but has not gained much practical momentum, and industrial spatiotemporal database usage is still in its infancy (Peuquet, 2001). Also, many of the attempts at creating spatiotemporal databases consist of merely extending the relational database model by tacking temporal data onto spatial data, which results in sub-optimal representations of regions and moving objects on a GIS (Peuquet, 2001).

Spatiotemporal data representation exploits the capabilities of modern computers to represent more than traditional geographic entities such as points, lines, and polygons. High-powered computers can also show the temporal nature of these objects (Renolen, 2000), if the data is modeled and queried correctly. Renolen (2000) describes a spatiotemporal information system (STIS) as an “information system where the spatial location and temporal history... are of interest to organizations.” This definition can be

critiqued as not explicitly stating that the information systems actually contain spatiotemporally referenced data, instead the literature only says that the spatiotemporal data is of “interest to organizations.” Nevertheless, this literature provides a good analogy of maps to conceptual data models (such as data flow diagrams), and shows how some conceptual modeling methods can be used to construct STIS. The models selected as being useful are entity-relationship, activity, object-oriented, and activity models (Renolen, 2000). The author discusses entity relationship (ER) and time modeling languages, which are languages that time stamp conventional entities. Tryfona et al. (1999) takes ER modeling a step further by adding temporal demarcations to entities in ER diagrams. STER is an acronym meaning spatio-temporal entity relationship diagrams (Peuquet, 2001).

Adding to the growing list of spatiotemporal acronyms are, STAM, which means spatiotemporal access methods, and spatiotemporal database (STDB) (Tzouramanis, 2002). One goal of STDB is to use efficient indexing methods to reduce the time it takes to query spatiotemporal objects. STAMs include the ability to generate “synthetic” data, which is statistically produced data relating to real-world phenomena; sets of real data; query processors; and visualization tools (Tzouramanis, 2002).

According to Frihida et al. (2002), very large data sets are accumulated when monitoring traffic flows, and this data should be monitored both geographically and temporally. But monitoring spatiotemporal data has its difficulties. The SQL queries necessary to model spatiotemporal data are long, and database seek and retrieval times can be prohibitively high (Frihida et al., 2002).

Perhaps one of the most interesting types of GIS is multimedia GIS. Multimedia GIS can improve the end user's perception of reality while using the system, and might be able to "open a whole new dimension" to the way GIS is used (Cartwright, 2001). Pissinou et al. (2001) discuss geographic digital libraries and the use of these in multimedia GIS. However, inadequacies in spatiotemporal data paradigms are resulting in the need for new spatiotemporal data models (Pissinou et al., 2001). In digital video, the intra-object spatial composition and intra-object temporal composition are two methods of spatiotemporal description. These authors propose a geographic topological-directional model (GTDM) to incorporate these and other concepts into spatiotemporal geographic video sequences. In this model they specify data operators, such as meet, overlap, and during. This literature states that the GTDM can be used for vehicle routing, which might make it a useful tool for online grocers.

Sperry et al. (2001) say that geographic objects change in thematic and temporal ways. Thematic changes can be more readily handled than temporal changes, however. Objects can have "filial" links to each other by being parents and / or children. This is called the lineage model. An important aspect of the lineage model is that it allows remote databases to be updated with spatiotemporal changes that have occurred since the last update, without transferring the whole database in the process (Sperry et al., 2001). This model is referred to as the update model by Zhang and Hunter (2000), who list three other models. They are the snapshot model, which simply superimposes a new layer onto the coverage at successive time intervals; the event based model, which links cells by ordered sets of events; and the 4-D model that incorporates time in a similar manner as other spatial dimensions.

Tryfona et al. (1999) highlight the need for spatiotemporal data manipulation solutions for applications such as routing and forecasting. Their literature discusses the peculiarities of spatiotemporal data and applications by classifying objects into categories of objects that change continuously, change discretely, or have continuous motion accompanied by changes in shape. Investigation of this type of research may show a correlation with this type of object analysis and the delivery zones that I am suggesting in this dissertation. Another perhaps relevant point of Tryfona et al.'s (1999) literature is the description of *chrons*, which are individual time values that are taken from "time domains."

"Evolving regions" are discussed by Claramunt and Jiang (2001). This concept is close to the grocery delivery regions that I am suggesting, except Claramunt and Jiang's (2001) evolving regions do not address profitability thresholds in the context of online grocery stores. Despite this, these authors' research does address the temporal validity of evolving regions as being only valid during the intersection of the "life spans" of the regions. The important point here is that that "life spans of regions" does not infer that the regions disintegrate after they "die." It means that certain properties of the regions in question cease to exist. Perhaps profitability can "die" for an online grocer's delivery region if it decreases under a certain threshold.

Abstract data types are used by Erwig et al. (1999) to show moving and evolving spatiotemporal objects. Abstract data types are many-sorted algebras, which contain object types and the operations that influence the objects. For example, two abstract data types are *mpoint* and *mregion*. Both of these types are influenced by time as they move through space (Erwig et al., 1999). According to these authors, two steps are required to

create a spatiotemporal data model using many-sorted algebra. First, data types and the operations between them are provided names. Names of data types are called sorts, and names of the operations are called operators. Assigning sorts and operators is referred to as giving the abstract data type a signature. Erwig et al. (1999) say that by using spatial algebra, which essentially consists of mathematically depicting moving points as arcs and moving polygons as polyhedra, modelers can describe spatiotemporal movement with “unlimited expressive power.”

### **Other Supporting Literature**

It is hard to imagine any logistical solution that does not incorporate GIS. However there is an opulent amount of literature that pertains to e-logistics which does not necessarily address GIS. Because the subject of e-logistics is germane to delivering groceries via online orders, some e-logistic related literature is reviewed in this literature review.

There are various definitions of what “e-logistics” actually means. Generally, E-logistics focuses on using internet technologies to make supply chains easier to manage. It could also be safe to define it as using e-commerce technologies, such as web-enabled logistically related flows of information and images, to facilitate and optimize the logistic efforts of an organization.

A valuable contributor to the body of e-logistic literature is the automotive industry. Recently, e-logistics has taken on a very large role in allowing car manufactures to cut their lead time, or the time it takes to get a new car to market, to a fraction of the time it was a few years ago. Add to this fact the recently acquired capability of consumers to specify online what kind of automobile they want, and the picture should become slightly

clearer about the magnitude of how intricate the logistics must be to get the parts to the manufacturer, and the car to the customer within a specified period of time. Although the processes involved in packing and delivering groceries may not be as intricate as those involved in manufacturing cars in accordance with web orders, many of the principles involved in satisfying customized automobile orders can apply to customized grocery orders. Automotive Design and Production magazine has various articles that recognize the essential role e-logistics plays in car manufacturing (Gould, 2001). "Today's logistics involves sophisticated supply chain management applications infused with collaborative capabilities, all running on top of an internet-based e-commerce infrastructure - and fully integrated with back-office information systems to create a seamless system from product development to delivery."

Gould's (2001) article also provides a comprehensive, yet succinct, account of various aspects of logistics, such as third party logistics providers, fulfillment service providers, lead logistics providers, logistics exchanges, and logistics visibility providers. Naturally, the terminology in the field of logistics is growing as the discipline becomes increasingly more sophisticated. This is most likely because of the growing amount of information technology that is required to use logistical solutions.

Of course, package delivery firms should be implementing modern logistical solutions. UPS is one delivery firm that is aggressively utilizing e-logistic technology. A fully-owned subsidiary of United Parcel Service is called UPS e-Logistics. It offers a "supply chain solution" for B2B (business to business) and B2C (business to consumer) companies. The solution includes automated inventory availability, delivery requirement, and fulfillment capacity information. The subsidiary handles web, telephone, and mail-

based customer orders and delivers orders to a “majority” of United States addresses within two days (UPS Business Solutions, 2002). The description of these UPS services can be considered a compact sub-definition of e-logistics. The UPS e-Logistics services are like a “plug and play” solution for businesses. Of course the solution as explained by UPS is a significant oversimplification of the average corporate logistical business strategy; nevertheless, the idea of using an e-logistic provider is definitely intriguing, and is catching on in popularity. Documented instances of large corporations saving millions of dollars through e-logistic solutions are rife.

For example, Winn Dixie used Manugistics to recently implement an e-logistics solution that ties together 1,000 stores with 13 distribution centers. In addition, Wal-Mart and Dell are incorporating e-logistic strategies to keep inventories minimal and allow for better build-to-order capabilities. This early adoption of e-logistic technologies and processes should indicate that not only the concept of e-logistics is viable, but should also suggest that the omission of e-logistics from any comprehensive retailing e-commerce strategy, such as that of an online grocer, could render that strategy incomplete and possibly insufficient.

Jennifer S. Kuhel (2002a) , writing for Supply Chain Technology News, explains how the execution of logistical plans cannot take place in a silo (Kuhel , 2002a). According to Kuhel (2002a), logistics is a participatory discipline that, in order for it to succeed as an inter-organizational tool, must be implemented by all participating companies. Encapsulating this thought is a term called “collaborative logistics,” which also implies using internet technology to coordinate inter-organizational logistical entities. The recognition of this term can help underscore the value of collaboration among people

who pick and pack the groceries, the employees who monitor the GEOS, and the delivery truck drivers.

An important point in Kuhel's article (2002a) is the quote by Bob Obee, CIO of Roadway Express logistics, who said, "I'm shocked by the single-digit percentages of bills of lading that are electronically tendered to us." This means that most companies are not even close to being ready to collaborate logistically, at least not on any type of technological level. This fact bolsters the necessity for this type of research that aims at informing online grocery startups about the many aspects e-logistics that can make grocery delivery a profitable business.

Kuhel's article (2002a) continues with the "Seven Immutable Laws of Collaborative Logistics" which are stated by John Langley, logistics professor at the University of Tennessee. The seven laws essentially state how important collaborative logistics is for the secure movement of "information, products, assets, documents, and capital." One particularly noteworthy item in Langley's list is the secure movement of "information." Langley, whether knowingly or not, touches on the new concept of the "information supply chain." This is the awareness and exploitation of information as it progresses through the supply chain. Because supply chains do exist within a company, such as between warehouse operations and outbound logistics in a supermarket, the information supply chain is important to online grocery initiatives.

One notable company that has especially been under the gun to establish an e-logistics system is Unilever. Nash (2002) tells of how the giant corporation, which has more than 900 brands in 150 countries, is earning less profit than its closest rival, Procter and Gamble (Nash, 2002). Unilever's warehouses are not optimally located, and trucks

are covering too much ground to deliver products. Although the company has 100 separate SAP ERP systems, a lot of money is being lost due to the logistical inefficiencies. This fact emphasizes the point that although ERP has been implemented to streamline information flows throughout the enterprise, the ERP systems are insufficient when it comes to optimizing the movement of goods. The article states that the location of Unilever's customers is a large determinant of what e-logistics system the company will employ. To reemphasize, the fact that even such a large company such as Unilever, which had the providence to implement sophisticated ERP systems, has discovered, like many other organizations, that essential cost saving functionality is not contained in the ERP systems. Therefore, in the case of already established online grocers that do have ERP initiatives, more emphasis must be placed on the optimal movement of groceries and trucks by sophisticated spatiotemporal e-logistic systems.

In the same article, Fred Berkheimer, director of Unilever's North American logistics department, said that transportation costs will be decreased between 10 and 12% after distribution centers are relocated based upon customer location. Needless to say, for a company of this size, this cost savings will be great. Much of the savings will be because trucks will be able to run at 20% greater capacity than they have been before the distribution centers are optimally located.

The value of efficient intra-corporate logistics, which of course is the main concern of online grocers that deliver, is accented by Hackler (2002) who says, the level of efficiency in routing components and packets (envelops containing important documents) within a company becomes more important when (inter-corporate) supply chain partners are depending on the efficiency of any individual company (Hacker, 2002). This is where

internal parcel tracking systems come in. Many parcel tracking systems use bar code scanners, wireless devices, online lookup, and e-mail as their internal logistical tools. But Hacker (2002) says nothing about the incorporation of a GIS system in the parcel tracking system to visually show where any component or packet is within the enterprise. The article does say, however, that efficient parcel tracking systems can reduce delivery times by 80%.

A brief mention of how grocers can generate coupons for customers depending on their purchases using a technology called “analytics” is important. Because analytics should play an integral part of an online grocer’s operations, a review of some analytics-related literature follows.

As with most cases of information technology-related terminology, analytics can have a different definition depending on who is doing the defining. Wayne Eckerson (2002), director of education and research at The Data Warehousing Institute says that analytics, or “enterprise analytics” are terms that really encompass most business intelligence technologies such as content management, GIS, enterprise application integration (EAI), text mining, OLAP, collaboration, and more.

Jennifer Maselli (2002) writes about how Siebel Systems, a leading customer relationship management (CRM) solution vendor, is witnessing growth in demand for its analytics functionality more than any aspect of its CRM solutions. In the same article, a Gartner survey shows that more than half of businesses surveyed say that they are planning on increasing their CRM analytical capabilities.

Reduction in the time to analyze and redistribute data is a competitive advantage (Foley, 2002). According to Foley (2002), it is important to provide reports to senior

executives that include real-time information about things such as tracking the process of orders as they originate from the retail customer, to the movement of products from the warehouse, and on to store shelves. The article calls businesses that use this type of model as “real-time businesses.” This is of course should be one of the objectives of online grocers as they dispatch delivery trucks in accordance with the generation of real-time delivery zones.

The need for better analytics among the supply chain has not gone unnoticed by major ERP / SCM (supply chain management) vendors. For example, Manugistics has unrolled their Process Analyzer solution that uses OLAP capabilities in Microsoft’s SZL Server 2000 database. Rick Whiting (2002b) tells how Manugistics is concentrating on incorporating new analytical capabilities into supplier management applications. These applications are supposed to facilitate the rating of suppliers by using metrics such as percentage of on-time deliveries and degree of product quality. Manugistics’ business intelligence software includes predefined benchmarks for cycle time, work in progress, productivity, workload, and resource usage.

David Tompkins (2002) supports the argument that effective supply chain management requires “up-to-the-second monitoring” and total visibility across disparate supply chain systems. In his article, Tompkins (2002) explains that necessary real-time analytics should be based on a decentralized or multi-enterprise systems configuration, which basically refers to implementing real-time monitoring solutions on an “extended enterprise” model

Because of the importance of web services for not only interoperability, but also because of the potential of the technology to facilitate the implementation of GEOS, a further review of web services-related literature follows.

Johanna Ambrosio (2002) provides some perspective to the course of events that are taking place that can lead to the adoption of web services by enterprises. She says that ERP has approximately 70% worldwide penetration, with supply chain and customer relationship management (CRM) at 40 and 30% respectively. This give a good indication of the fundamental trend of companies to optimize decision making by marshalling data, and making that data available in real time to supply chain partners. Enterprise application integration (EAI) is one way to connect software from these general types of information systems. But EAI is not always efficient enough to perform impeccably well. Ambrosio's (2002) article tells how web services could become the "next EAI generation," by filling in many of the EAI's.

David Truog, a Forrester Research principal analyst, states in Ambrosio's article that the cost of application integration should drop because of web services. Reinforcing the assertion that web services will indeed be a next generation of distributed applications is Peter Fischer's (2002) article, which gives a succinct and clear picture of how valuable web services can be for information visualization. According to Fischer, web services will permit collaboration in a peer-to-peer manner. This primarily means that the middle layer (middleware, EAI, etc) will become transparent to computers communicating over the internet, even if the communicating computers are using disparate and theretofore incompatible applications. According to Fischer (2002), web services will become the "glue" that makes components (applications) interoperable.

Albeit minimal, Fischer (2002) gives some mention to the construction of a “dashboard” made from web services. Although the term “dashboard” can have different meanings, the article describes dashboards as corporate portals comprised of “portlets.” A portlet could be considered a central collaboration zone for supply chain partners, providing the partners with access to data, groupware, spatiotemporal images, and more. Electronic data interchange (EDI) has been one of the ways supply chain partners transferred data between themselves. EDI has been notoriously expensive to implement, however. The high cost of EDI has effectively limited the utilization of the technology to larger supply chain partners who could afford the expense. Web services might be used as an alternate or augmentation to EDI solutions. For example, suppliers could be queried using web services to discover the amount of in-stock items before sending EDI purchase orders (Harreld Krill and Schwartz, 2002). Possibly, because EDI is so expensive, approximately 80% of products purchased over the supply chain are from suppliers not using EDI. According to Harreld, Krill, and Schwartz (2002), the time lag of hooking up a new supply chain partner to the EDI network could take months. web services could be used either as an interim technology before the EDI system is fully implemented, or totally used in place of the EDI solution. That is, if web services prove to be as useful in inter-corporate data exchange as EDI has shown itself to be to those corporations that implemented the technology.

David Litwack and Peter Fingar (2002) ponder whether web services will really eventuate into being the “next big thing.” In attempting to answer this question, Litwack and Fingar (2002) postulate that companies will first link internal computer systems with web services, and then concentrate on tying in business systems into the web services

paradigm. As an example, the article tells how much easier it is for a retailer and a logistic provider to coordinate and track the location of parts if both companies are using web services solutions.

Web services can allow maps to be composed of layers from disparate internet cartographic providers (Lowe, 2002). Moreover, the layers can be changed in real time without requiring the user to reconnect to the map-providing service. This functionality holds great promise for online grocer interior supply chain applications where the geographic flow of groceries, people, information, and money are relevant to all departments associated with the packing, loading, and delivery of groceries.

The location recognition capabilities of wireless have the potential to result in diverse and meaningful applications and strategies for online grocery deliveries.

Michael Cohn describes the potential benefits and some of the existing hurdles that must be overcome before location based services (LBS) become a widely-adopted technology. As for the benefits, Cohn (2002) explains how LBS can be used to optimize supply chain practices. He tells how, by using LBS, defective merchandise can be prevented from completing the assembly line process in order to prevent the defective merchandise from being sent to customers. Three big GIS companies – ESRI, MapInfo, and Autodesk - are developing LBS services. In one article, MapInfo's business unit general manager, Larry Delaney, predicts that many businesses, especially supply-chain related firms, will adopt LBS solutions after the technology becomes prevalent in consumer markets.

Microsoft has also become an important player in the market for LBS. Microsoft's MapPoint LBS platform is used by companies such as Hewlett Packard, Clarity, Action

Engine, and Intrado. MapPoint@ uses .NET technology, and is a web service that uses XML and "... lets developers integrate maps, driving directions, distance calculations, proximity searches and other location intelligence into applications, business processes and web sites."

Especially interesting is the "friend finder" that allows anyone connected to a wireless service to know the location of other people connected to the service. This type of service can possibly be applied to all entities in online grocery operations.

Some of the hurdles that must be cleared before LBS can truly be widely adopted are the compatibility issues of the different wireless standards such as global system for mobile communications (GSM) and code division multiple access (CDMA).

An interesting wireless technology exists that is supposed to allow centimeter-precise location detecting capabilities (Werb and Sereiko, 2002). Ultra-wideband (UWB) radio technology differs from conventional radio signal technology by not continuously broadcasting. Instead, a UWB transmitter sends pulses, which represent ones and zeros, in less than one billionth of a second. Basic UWB radios will be able to transmit at 20 megabits per second, with gigabit transmissions possible as the technology matures. Werb and Sereiko (2002) explain how many UWB radios can communicate without cross-interference - a feat not possible with conventional radio technology. Additionally, the technology allows for the manufacture of low power utilization, low cost, and high penetration (the ability to go through obstacles) radios.

So what does this mean for location discovery applications? Although an infrastructure capable of supporting UWB radios is still a few years off, companies have begun to develop applications that use the technology. Indoor wireless tracking

applications for hospitals and manufacturers are currently being devised. The Marines are working on a personnel location system using UWB.

UWB was approved for use in the United States by the Federal Communications Commission in February 2003. This approval, combined with the centimeter-precise location capabilities of the technology, can put the technology one step closer to being used by online grocery delivery solutions.

Carolyn April and Heather Harreld (2002) explain how collaborative “applications” are beginning to exist that “allow multiple applications and data sources to ‘talk.’” This definition of collaboration includes only the applications involved at the intra-organization or inter-organization level. Comprehensive collaboration solutions are, however, not limited to the underlying technology. Indeed, the need for human managers and executives to collaborate drives the development of the technology. Therefore care must be taken when differentiating between comprehensive collaboration models and the technologies that facilitate that collaboration. Nevertheless, in April and Harreld’s (2002) column, insight is provided about some of the technological components that enable applications to facilitate collaboration. Some such components are XML, and web services.

Julie Hahnke and Dan Sullivan (2002) talk about how collaboration is categorized into three primary groups. 1. Product management and supply-chain management (SCM). 2. Internet trading exchanges and marketplaces. 3. Information exchange applications. Online grocers should concern themselves with all three facets. These authors define supply chain management as “understanding demand trends and consumption patterns, as well as supply lead times to optimize production scheduling, manufacturing, and

fulfillment.” This definition also relates to managing partial fills, backorders, substituted products, warehousing, transportation and delivery scheduling.

The article states that, of the three groups above, the supply-chain collaboration group is the oldest, and the information exchange group is the newest. The specifics of this third group, which is still emerging and maturing, is hard to define, but the group is related to business intelligence, portals, content management, CRM, and knowledge management. It seems difficult, however, to clearly separate the groups, especially the first and third group. This is because comprehensive SCM solutions should include virtually all of the functions listed in the information exchange application group.

Collaboration application vendors are obviously becoming receptive to the needs of businesses, as evinced by the functionality incorporated in new collaborative portals. Mears explains that needed capabilities such as document sharing, colleague and expertise locating, and threaded discussions are incorporated in portals (Mears, 2002). Mears (2002) says, “portals are becoming the centerpiece of how companies do business.” This statement concisely implies a trend of allowing employees to interact increasingly through portals, and decreasingly thorough face-to-face contact. This trend could give rise to a lot of technological and strategic ramifications. One such ramification can be the difficulty of adoption of collaborative solutions. To address this issue, Corechange is supposed to allow users to both simply use the application while allowing business users to “set up community portal pages, decide who can be a member of that community and what content, applications, and collaboration features will be available.”

Yet, despite the product’s varied functions, evidently no geographic capabilities exist such as the ability to locate stakeholders or other physical entities.

The amount of literature pertaining to portals is growing quickly. Indeed, this is probably a corollary to the amount of expenditure going toward this technology. Giga Information Services predict the current \$80,000,000 total annual portal expenditures will grow to \$2,000,000,000 annually in 2005 (Frye, 2002).

Frye (2002) explains that because a portal is a “personalized” browser interface, users of portals will be able to communicate with, and be a distinct player within “multiple communities.” A great potential lies here in the simplicity of employees not having to personalize or adjust their computer’s desktop or network interface before participating in the delivery zone delivery scenario underway at any particular time. Frye’s article goes on to say that web services will add thrust to the usage of portals because of the ability of web services to overcome interoperability glitches that thwart the unimpeded implementation of portals between disparate systems within the supply chain. While saying that portals should include “presentation, personalization, collaboration process(es), publishing, and distribution,” Frye (2002) also said that a current trend could be the movement toward “federated portals.” This is essentially the ability to access a single enterprise portal by multiple portal “communities.” Although the article does not clarify if the communities are inter- or intra- organizational, it is assumed that the federated portals could exist both within and between corporations (in the supply chain).

Steve Konicki (2002) discusses how retailer supply chains can save \$40,000,000,000 annually by using better collaboration. In his article the importance of UCCnet is described. UCCnet is a standards body that is building an all-inclusive central registry, called the UCCnet Global Registry that will contain information about all retail products.

This registry could facilitate the dissemination of valuable retail product information to smaller retailers, such as small online grocers, and make them more competitive.

The UCCnet Global Registry will contain 62 pieces of information about every product. Package size, product number, and manufacturer are some of the information that will be available about each product. Konicki's (2002) article declares the registry to be a "historic breakthrough" that could decrease the time it takes to update changes about products throughout the supply chain from weeks to, possibly, minutes.

Konicki (2002) describes how collaborative planning, forecasting, and replenishment – parts of an integral supply chain optimization model – can be greatly facilitated by a central registry. Collaborative planning, forecasting, and replenishment can allow retailers and manufacturers to transfer data about products to coordinate forecasts, replenishment schedules, and overall collaboration. A central product registry, such as the UCCnet Global Registry, could significantly increase the viability of the collaborative planning, forecasting, and replenishment model.

Obviously there is no paucity of new technological methodologies that, if used by astute online grocers, could make their logistical and overall fulfillment operations competitive and profitable. This Literature Review necessarily encompasses a wide variety of up-and-coming and established technologies and delivery practices. A problem does exist, however, for online grocers to decide which technologies and practices to choose from. A main purpose of my incorporation of the myriad facets of related technologies and logistical trends is to at least provide online grocers (and potential online grocers) the background knowledge necessary to intelligently begin to decide what to implement in their delivery initiative.

## SIMULATION ELUCIDATION

This section demonstrates, by way of images taken from my logistical computer application, how a grocer can simulate the delivery of trucks to a hypothetical delivery area. The application uses Microsoft Excel™ as the underlying program. The user of the program, however, will have little indication that he or she is actually using Excel™. This is because I customized the application with Visual Basic for Applications (VBA) code. The application, when used by a grocer, will be run on a high-powered back-end computer. What follows is just one of virtually thousands of possible profit-maximizing (or profit-ascertaining) scenarios that a grocer who has plans to deliver can step through to determine such things as the amount of trucks required, time to deliver to a region, and more. The following screen shots document that dozens of variables can be input into the application such as desired profit, inter- and intra- delivery times (within and between regions), regional population, and more. Also, the simulation user can specify how many times the simulation can be run. The application also creates various reports “on the fly,” which can be viewed by the user after the simulation(s) run through.

The simulation can be run from one time to thousands of times. The Simulation Options form is opened with the press of a button. The logistical simulation is a sophisticated computer application that I programmed, which includes 645 pages of Visual Basic for Applications code (measured in 12-point, single-spaced type), and is comprised of 337 macros, 88 spreadsheets, 66,000 data elements in the form of addresses, scores of functions, and procedures, and random number generators which are all

compiled into a fully functional logistical decision-making application that is driven by algorithms that I devised.

The application can be utilized by both beginning and established grocers. All that is required of these grocers, besides the necessary computer platform, is to perform a survey of at least its current customers to collect some idea of the amount of deliveries that might occur in each delivery region.

A grocer who is considering a delivery initiative should first take a survey of at least his existing customers to see if there is interest in having groceries delivered to the home or region that the customers live in. Even though the purpose and scope of my dissertation is not at dependant on survey results, some of the questions on a survey taken by a grocer who is considering using my computerized logistical decision facilitating tool might be similar to the following.

- How long have you been a customer at our store?
- What is your average weekly grocery bill at this store?
- What is your average weekly grocery including purchases at this store and other stores?
- What is your zip-plus-four code?
- If you do not know your zip-plus-four code, what is your address?
- Would you be interested in having our store delivery groceries to your house?
- If you would like groceries delivered, how much per week (in dollars) would you guess that you might order from us to deliver to you?
- May we call you about this?
- If we can call you, what is your phone number?
- Would you be using the internet to place your order?

The grocer could also ask other questions that he or she believes is relevant or appropriate. For example, asking the customer to supply his or her name may, or may not, be conducive to getting more accurate responses.

The survey forms may be generated with the sales receipts, and possibly something, such as two or three free apples, may be offered as an incentive to fill out the survey.

Once the surveys have been accumulated, and the addresses (or zip-plus-four codes) are gleaned from the surveys, the addresses are simply plugged into the application's underlying database.

From the information on the surveys the grocer can determine, within bounds, how many orders will be generated within a certain time period. For example, if, according to the surveys, it is determined that there will be 1500 home deliveries per week, the grocer simply inputs "1500" into the Amount of Orders dropdown list (Figure 1), and inputs "7" into the Duration of Delivery in Days dropdown list (Figure 2).

A "Pause Every" function is also provided. Because the simulation can run quite fast, it might be hard for the user to see the exact status of the trucks or the amount of deliveries sent to each region. The Pause Every function allows the user to specify when to temporarily halt the simulation so he or she could better see the status of the simulation. The user can make the simulation pause when every few orders are generated, or every thousand, or more orders are generated. To do this the Pause Every function is used on the user interface.

The Main Map shows a prototypical delivery area divided into 66 hexagonal regions (Figure 1). Naturally, each grocer's customer market area will have a different geographical shape. But, for purposes of this simulation, a somewhat key-shaped area is

depicted on the screen (Figure 2). This is not to suggest that the pre-determined shape of the customer market area is a trivial matter, however, my assertion is that this shape is a reasonable manifestation of what could be a collection of geographic regions that has, say, a river to the west, mountains to the north, and possibly a sea coast surrounding the east and south perimeters. Although this is an arbitrary shape, the underlying principle of visualizing and recording the deliveries can be applicable to any area if the hexagons are rearranged accordingly. But the rearrangement of the hexagons is not part of the functionality of this application.

As mentioned, a grocer should want to discover the conditions where an online e-grocer (or a grocer who is taking orders by a telephone) will reach a predetermined amount of profitability. By predetermined, I mean that before each simulation sequence is executed, the user can input exactly what profit is required per delivery run to a region, from 0.1% to 3%.

The Profit Options button is pressed to show the Profit Options form. Then the Profit Margin (in %) drop down list is pressed, showing the range of profit as described below (Figure 3).

One-tenth of 1% profit is represented by 0.01, and is the lowest setting. 0.1 means 1% profit. While 0.3 means 3% profit, the highest allowable in this application.

The Minimum Dollar Delivery drop down box allows the merchant to specify from \$5 to \$100 (Figure 4). This of course means that the grocer has created a business plan, and has notified customers that any orders of less than this amount will not be able to be delivered. Any order amounts generated by the random number generator that is less than

this amount will be rejected, and the random number generator will generate another number.

The Mandatory Profit calculation for a region is (Profit Margin x amount of groceries ordered at an individual residence) + (the delivery charge for an order sent to that region). Therefore an order of \$100 with a profit margin of 1% sent to a region with a \$5 delivery charge per order will generate  $(100 \times .1) + (5) = \$6$  in profit. If the Mandatory Profit for that region has been specified as \$18, it will require three of these identical orders to reach that region's Mandatory Profit and have a truck dispatched to that region.

The application allows for an overall Mandatory Profit amount to be input, or different Mandatory Profit amounts to be input for "concentric regions." The hexagons are geometric shapes which can naturally be concatenated into rings or "buffers" around a central point. My application allows the merchant to specify different Mandatory Profits for each concentric region. Perhaps, a lesser Mandatory Profit would be specified for closer concentric regions, allowing trucks to be dispatched to those regions with greater frequency. Figure 5 shows a \$45 Mandatory Profit setting for all of the regions.

Figure 6 shows gradually increasing Mandatory profit settings for all concentric regions radiating out from the Home Region. The increases are graduated in \$5 increments.

As mentioned above, the delivery charge can be from zero to any amount the merchant may require. In Figure 6, the text box next to the "Delivery Charge (in dollars)" allows for the input of a global charge that is added to every order delivered to every region. A "5" put into that box will assign a \$5 delivery charge to every region. When the

“Submit Delivery Charge” button is depressed, the value in the text box is relayed to the Delivery Charge Per Region map. As seen in Figure 6, each region contains “5” since this amount was submitted from the Main Map screen. The Profit Options form stays visible in case the user wants to reenter another global value. The Set Regions to Null button on the Delivery Charge Per Region map in Figure 6 clears out all of the delivery values in every region.

To set the delivery charge of any individual region, the user simply has to click on the hexagonal region and a form will pop up. Figure 8 shows the results of a user clicking on Region E4 to enter a Delivery Charge of \$10. The Delivery Charge per Region form pops up with the phrase “Region E4 Delivery Charge” to clearly show what region’s delivery charge is being changed. Pressing the “Submit” button will put a “10” in Region E4. Notice areas selected turn red when clicked on. After setting the Delivery Charges, pressing the Main Map button will bring the user back to the main control panel.

The Simulation Options button (Figure 8) on the Main Map opens the Simulation Options form and also displays the words “Simulation 0” near the top left of the screen. Two tabs are on the Simulation Options form – the Number of Runs tab and the Population Options tab. Using the Number of Runs tab the user can choose to run the simulation from two to 1,000 times.

The Number of Runs tab has two mutually exclusive radio buttons. Choosing the Same Time Window button will make each successive simulation run through the same times. For example if two days are chosen and the beginning time is 1am, May 1, all the simulations for that sequence will run from 1 am, May 1, to 1am, May 3.

If, however, the “Successive (concatenated) Times” radio button is chosen with a two day, two simulation sequence, then the first simulation will run from 1 am, May 1 to 1 am May 3; and the second simulation will run from 1 am May 3 to 1 am May 5. The Run the Project button of course initiates the simulation. If the Run the Project button is pressed without selecting any options, as is the case in Figure 9, various error catching functions will initiate. As shown in Figure 10, the first error message that occurs tells the user that no simulations can be run without choosing the Number of Orders.

After pressing “OK” on the message box, the user chooses “500” from the “Number of Orders” drop down list (Figure 11). The Run the Project button is again pressed. But as Figure 12 shows, the simulation will not run without specifying how many days the simulation should run for.

The “OK” button is pressed on the error message box and a two day Duration of Deliveries is selected (Figure 13). Figure 13 also shows the Gross Orders per Simulation legend. This legend shows how the hexagons will change color in respect to the amount of total (gross) orders that were placed in a simulation. This means that the color of the hexagon has nothing to do with the number that is in the hexagon after the first delivery truck returns from making deliveries to that hexagonal region.

Here are two important definitions. 1. RUN. A run is the dispatching of a truck to a region, the delivery of groceries to all addresses that placed orders in that region, and the return of that truck to the grocery store. The grocery store is located in Region H. 2. SIMULATION. A simulation can be comprised of many runs to each and every hexagonal region. During each simulation, after a truck returns from a delivery to a specific region, the number inside that region’s hexagon will become “0.” This means

that there are zero orders called in so far for the next run. As soon as one order comes in for that region, the number inside that region will become “1,” and will increase as more orders come in, and will continue to increase until that region reaches the predetermined Mandatory Profit, at which time a truck will be dispatched; and when that truck returns the number in the hexagon will again become “0.” This sequence will occur for the duration of the simulation for every hexagonal region in the entire area.

A hexagon’s color, on the other hand, will continue to change in proportion to, and in concurrence with the colors shown on the legend. The colors in the hexagons tell the user of the application the total number of orders called in by households in that region. The color continues to change for the duration of the simulation. The colors of all hexagons become purple when the Reset Regions to Zero button is pressed. In other words, as a simulation is running, the Main Map shows, in color-coded regions, the total amount of orders that has come in from that region.

When regions meet their Mandatory Profit, trucks will be dispatched to those regions. The number of the truck that is dispatched appears clearly to the left of the simulation screen. Truck dispatch notifications tell when a truck is dispatched, and when it returns. Above the truck dispatch notifications is the time the simulation began, and the time it ends.

The color-coded legend is provided to conveniently see how many orders have been generated from a region at any time. The numerical value that appears in a region is the amount of undelivered orders that have been generated from that region. The number turns to zero when a delivery is made to that region. Figure 14 shows the Main Map after a two-day, 500 order simulation was run.

At this point it is important to emphasize that it is impossible to capture the dynamic nature of this simulation application by looking at the static screen shots in this dissertation write up. Because the simulation is also a fully functional working prototype of a logistical interface, the dispatching and returning of trucks occur in real time which is completely unapparent to anyone merely looking at static screen shots.

Figure 14 shows the number 500 in the top left (to the left of “ORDERS PLACED THIS SIMULATION”). This is the total (gross) number of all the orders called in or placed through the internet to all the 66 hexagonal regions. This number includes orders that were delivered to, along with orders that have not as yet been delivered to residences in the regions. The numbers that remain in each of the hexagons are the number of orders within each hexagon that have not been delivered yet. This information is also stated in white letters to the right of the junction of regions E8 and F7.

Notice the “First Order Was Placed at:” and “Last Order Was Placed At:” times. These times will always reflect the duration specified in the Duration of Deliveries of Days drop down list.

The “Truck (number 1, 2, 3 ... 15) dispatched to Region (H, A1, A2 ... G4)” notices on the upper left of the screen appear every time a truck is sent to that region. The red “Insufficient Amount of Trucks” means that the 15 trucks available during this simulation were not enough to deliver one order per run.

Figure 15 shows the results as displayed on the Report Dashboard. Notice the “NO SIMULATION OPTIONS WERE CHOSEN BEFORE RUNNING THIS APPLICATION.” This is because no options were chosen from the Simulation Options form.

The vertical bars show the total of orders called in from each region, with each bar representing a different region (hexagon in Figure 14). Notice the time the simulation ran is clearly displayed near the top of the Report Dashboard. The Main Map button returns the user to the Main Map. The other buttons will be explained below.

So far, we have created a non-optimal situation, meaning that although we looked at the Profit Options form, we have not mandated any Profit Options yet for any simulation sequence. The colors of the hexagons in Figure 14 are associated with the colors legend in the same figure. The values of the hexagonal regions match the values of the associated regional bars in the Figure 15. This is to make it easy for the users of the application to see how many orders were generated from each region.

For the next simulation, the profit margin, minimum dollar delivery, average dollar delivery, mandatory profit, and delivery charges, will be set in order to stipulate and fine tune the exact criteria that we want, or in other words, dictating the “pathways by which profitability can be achieved.” This is an important point, and one of the underpinnings of the purpose of this logistical application. We are creating a progressively more sophisticated “combinatorial situation as we progress.

Figure 16 shows results of the simulation. The preset profitability settings are clearly visible in the Profit Options form. Notice in Figure 16 that fewer trucks were needed when Profit Options were specified than when no Profit Options were set. This is because in the prior simulation, a truck was dispatched as soon as a single order came in. In this simulation a truck is not dispatched until a region reaches its Mandatory Profit.

Figure 16 shows that at the time the 500<sup>th</sup> order was placed, trucks number one and three were at the home store. The other trucks were out delivering to their respective regions as clearly described near the top left of the Main Map.

Figure 17 shows the Pause function being used. Figure 18 shows the Profit Options used to run the simulation shown in Figure 16.

The reason for the “Pause Every” option is to allow the simulation observer to have a kind of a “breathing space” to let him or her see the state of the simulation in whatever increment that is desired. This is a new thing that I have devised to allow managers to make better judgments about how they might want to change some or all of the variables on subsequent simulations. This is significant in that it is just one of the various innovations I am providing to better ascertain the geographic scope of what is happening at any desired step of any simulation. Managers will be able to see at any predetermined interval exactly where the orders are coming from. This will give an intuitive feel about what regions, or clusters of regions are generating orders, meeting the mandatory profitability; and also of what trucks are out, and of what trucks are waiting.

The Figure 17 simulation’s settings are 10 days, 1,000 orders, and the Profit Options are shown in Figure 18. It was instructed to Pause at 500 orders. Take a close look at the message box in Figure 17. It tells how many orders have been generated, the amount of simulated hours that have passed since the beginning of the simulation (in this case 120, which is one half of the 10 day duration because the application was instructed to pause at 500 deliveries, or one half the total 1,000 delivery specification for the entire 10-day period. It also shows the current simulated time.

The application allows the user to specify pauses in increments from every 10 deliveries to every 5,000 deliveries. Also notice that the amount of trucks used is far less than the above simulations because the Mandatory Profit is set at \$70 (Figure 18). A zero delivery charge was also used (Figure 18).

So far the Suppress Dispatch Alerts radio button has been activated. This radio button, along with the Allow Dispatch Alerts radio button just below it allows the user to toggle between having a message box appear every time a region reaches its Mandatory Profit, and not having the message box appear. The Allow Dispatch Alerts is a useful tool that tells the person monitoring the logistical dashboard (the actual application on the screen) that it is time to immediately send a truck to that region. This is just some of the functionality that I incorporated into this application in order to create a prototype of an actual logistical interface for managers to use. My application is not just a simulation package.

Look at Figure 19 to see the Profit Options, and to see that the Allow Dispatch Alerts radio button is activated for the next simulation. Figure 20 shows the first Dispatch Alert that was generated for this simulation sequence. The “OK” button has to be pressed for the application to continue running.

Figure 21 shows the same simulation upon its completion. Just by looking at the Main Map managers can determine how many trucks were used, the time span of incoming orders, the amount of orders generated by each region, the amount of undelivered orders, and, of course, the Profit Options. But this information is only the beginning. The preponderance of useful data is in the underlying reports that are generated on the fly for each simulation sequence.

Figure 22 shows the Report Dashboard for the simulation shown in Figure 21. Pressing the Population Report will show the following data (Figure 23).

The Population Report shows that each region has 4,000 households as shown by the bar graph and the data in the chart. Also, the population chart can be updated in the software to reflect actual population numbers.

Notice that you can return to either the Main Map or the Report Dashboard from any report. The relative mandatory profit earned for all regions, for all simulations is shown in the Profitability Chart (Figure 24). Not many of the slices of this particular chart are remarkable, but this will change as we further fine tune some variables such as population and individual Regions' Mandatory Profit specifications.

The total Mandatory Profit per region is shown in Figure 25. This information is reached by hitting the Profit Chart button. The Profitability Quotient (Figure 25) is a number between zero and one that uses the sum total of the profit for all regions for that particular simulation, and divides that number by a divisor that results in the number between zero and one. It is used to compare the relative profit between simulations. The maximum, minimum, average, standard deviation, mode, and median values pertain to the simulation which column they fall under.

Figure 26 shows a subset of the data that is attained by clicking on the Residence Report. Notice that the amount ordered for every household, the time of delivery, the run number, and what region the household exists in is clearly shown. Notice that no orders of less than \$10 were called in, as per our specification.

The Settings Report for this simulation is shown in Figure 27. The top of the Settings Report reflects the information the user input on the Main Map interface.

The chart in the Settings Report shows the names of the regions on both the left and right hand sides, population that the user has input, the delivery charge (in this case, as specified, is \$5) the mandatory profit (in this case, as specified, is \$60).

The One-Way Drive Times and Intra-Regional Drive Times are also specified. A region's Intra-Regional drive time is the average time it takes to stop at a residence, drop off the groceries, and drive to the next residence. The application's default (pre-programmed) time for all the regions' intra-regional drive times is five minutes, as shown in Figure 27. Specifically, if there are 10 deliveries to be made to a region on a run, the total intra-regional drive time for that run is (10 deliveries x 5 minutes per delivery) 50 minutes. If the round trip drive time to a region (the time it takes to drive from the store to the region, plus the time it takes to drive back to the store (not including making the deliveries)) is, say, 70 minutes, then the total time from the dispatch of the truck from the store, until the time the truck returns to the store is (70-minute round-trip drive time + 50 minutes intra-regional drive time) 120 minutes.

We will look later at the ability of this logistical application that I developed to allow the user to "fine tune" the Intra-regional and One-way- drive times. But first, the Delivery Report is discussed. I ran a simulation using the same Profit Options and time window (two days) with 500 deliveries to generate the Delivery Report shown in Figure 28.

Figure 28 shows a subset of the information about the 500 deliveries made during the above-mentioned simulation. Notice that, again, this is an on the fly generated\_report, as all of the reports are. This is an important and valuable feature of the simulation I developed. Of course, by simply using the Print button on any of the reports, that report

can be printed through the print preview window. The Delivery Report shows the information as described in the column headings, which can be used by a grocer to ascertain further information about cyclical order times per residence.

Figure 29 shows the Simulation Options form open, with three simulations chosen using “How Many Time Would You Like To Run The Simulation” drop-down menu. Up to 1000 simulations can be chosen using this menu. Notice the “Simulation# 0” near the top left of the screen. This will change in accordance with the actual number of the simulation in the sequence.

The “in Successive (Concatenated) Times” radio button is checked. This means that each successive simulation will run in the following period (in this case, three days). If the “Same Time Window” radio button was selected, the application would continuously simulate the deliveries starting and ending at the same time. Successive (Concatenated) times means that the next simulation in the sequence begins at the immediate second after the prior simulation ended.

Figure 30 shows the simulation at the end of the third sequence. Notice in Figure 30, the “Simulation #” is “3”, which, in itself, shows that the simulation sequence has either entered or completed its third simulation of this three-simulation concatenated sequence. In this case it indicates that the simulation has *completed* its third simulation in this three-simulation sequence.

Figure 31 and Figure 32 are two Figures taken from the same report that is automatically generated when the Simulation Charts button is pressed from the Report Dashboard. The first bar chart is the same as is seen on the Report Dashboard. It is replicated on the Number of Orders per Region report for convenience. The following

three charts show the amount of orders generated from each region for each simulation in this three-simulation sequence.

Each bar in each graph of Figure 31 and 32 represents a region. Region H is the leftmost bar, and gradually progresses to Region G4, the rightmost bar. The top graph called “Composite Total of All Orders for All Simulations” graphically depicts how many orders for a region was generated by adding the number of orders for the same region from the graphs shown under “Orders Per Individual Simulation.” By looking at Region H, we can see that in the first simulation 5 orders were called in from that region. In simulation 2 Region H generated 8 orders, and in the third simulation it generated 4 orders. Therefore, the Composite Total (the topmost graph) for Region H shows  $(5 + 8 + 4 = 17)$  that the total amount of orders for all simulations is 17 for Region H. This functionality will work even if 5,000 or more simulations are run – meaning that 5,000 “Orders Per Individual Simulation” graphs will be automatically generated and totaled in the Composite Total of All Orders for All Simulations graph on the top of this part of the logistical dashboard.

First, notice in Figures 31 and 32 that the times are concatenated for simulations one and two. The chart under the “Composite Total of All Orders For All Regions For All Simulations” is the total of all the charts that follow it.

Each bar in each chart from simulation one through simulation three is the amount of orders generated from that region for that simulation. Notice that the times above each bar chart represent the time window that that simulation was run. These times, like everything else on these bar charts are automatically generated.

Notice in Figure 33 that the Settings Report, which is automatically generated, shows the settings as input at the beginning of this simulation sequence. Figure 34 shows that the total mandatory profit for the three simulations was automatically recorded, proving that the logistic application that I developed can generate data for more than one simulation on the fly.

Figure 35 shows a subset of data from the Residence Report. The multiple pages of the Residence Report could be shown here, but the purpose of this Figure is to show that data from all three simulations has been recorded. For each successive simulation in this simulation sequence, Figure 35 shows the amount of groceries ordered, time of order, address of the ordering households, run number, and regions from all three simulations.

Figure 36 shows the Mandatory Profit being set by regions. Setting the Mandatory Profit by Concentric Region is another way the grocer can fine-tune his business model. For example, if the grocer would rather deliver to farther regions only when a greater profit is realized from those distant regions, he could set the concentric regions accordingly; precisely as was done in the simulation related to Figure 36.

Figure 37 shows the Settings Report for this simulation. Notice that the Mandatory Profit has been recorded as being set by \$5 increments, as we specified at the start of this simulation (Figure 36).

Figure 38 shows the same Profit Options as the prior simulation, but for this simulation, the “Submit Delivery Charge” button will be hit, bringing the Delivery Charge per Region interface into focus. This interface is shown in Figure 39

The Delivery Charge per Region interface allows the grocer to further fine tune the business model. When a user clicks on any region, a form will appear allowing that

user to change a delivery charge for what ever region (or regions) he wants to. Figure 40 shows the result of clicking on Region A3. Notice that the region clicked on turns red, reminding the user what region(s) he has changed.

Figure 41 shows that the new Delivery Charge of \$15 has been input into region A3 after the Submit button was depressed. When the simulation is run, a delivery charge of \$15 will be calculated into Region A3's profit and dispatch functions.

The Profitability Chart for this simulation, as displayed in Figure 42, provides visual evidence that Region A3's profit is proportionately greater than the other regions because of the five-times greater delivery charge that is calculated into every delivery to Region A3. The Profitability Chart can be thought of as a "profitability pie," which at a glance gives managers an intuitive, yet accurate, visualization of what delivery regions are generating the greatest, least, or mid-range profit. It is a part of the overall decision facilitating logistical dashboard that is integral to this application.

The numerical representation of the proportionate regional profit is shown in the Profit Chart for this simulation, as displayed in Figure 43. As with all of the data and images displayed in my dissertation, the data displayed in Figures 42 and 43 are generated on the fly with every simulation, and is very simply viewed by clicking the buttons of the intuitive application that I developed.

Figure 44 shows the Main Map and associated settings that were used for a simulation where the Intra-Regional Drive Time functionality was used. A region's Intra-Regional drive time is the average time it takes to stop at a residence, drop off the groceries, and then drive to the next residence.

Recall that all the above Settings Reports (such as the one in Figure 25) showed “5.00” in the Intra-Regional Drive Time column. The application’s default (pre-programmed) time for all the regions’ intra-regional drive times is five minutes. This means that, if there are 10 deliveries to be made to a region on a run, the total intra-regional drive time for that run is  $(10 \text{ deliveries} \times 5 \text{ minutes per delivery}) = 50 \text{ minutes}$ .

Using this same scenario, if the round trip drive time to a region (the time it takes to drive from the store to the region, plus the time it takes to drive back to the store (not including making the deliveries)) is, say, 70 minutes, then the total time from the dispatch of the truck from the store, until the time the truck returns to the store is  $(70 \text{ minutes round trip drive time} + 50 \text{ minutes intra-regional drive time}) = 120 \text{ minutes}$ .

Pressing the “Intra-Regional Drive Times” button brings up the screen in Figure 45. Clicking in any region will allow the user to change the Intra-Regional Drive time for that region. Figure 46 shows the result of clicking in Region D1 and inputting an Intra-Regional Drive Time of 15 minutes.

Figure 47 shows a subset of the data in the Settings Report that was automatically generated when this simulation was run. Notice that Region D1’s Intra-Regional Drive Time is 15 minutes, as was specified before the simulation was run.

The Delivery Report that was generated for this simulation (Figure 48) shows the Round Trip for two delivery runs to D regions. Even though both deliveries have comparable Gross Regional Profits, the delivery run to Region D1 took substantially longer than the run to Region D6. Of course, this is because it took on an average of three times longer to drive between residences in Region D1 than it did in Region D6.

The same start-up settings that were used in the prior simulation sequence were used for this next simulation sequence. The One-Way Drive Times for two regions were set manually for this simulation.

The application sets one-way default drive times to each region in minutes, as follows.

- Region H = 10
- A Regions = 15
- B Regions = 20
- C Regions = 25
- D Regions = 30
- E Regions = 35
- F Regions = 40
- G Regions = 45

A truck's round trip drive time is the one-way drive time multiplied by two. The application calculates a trucks' total time to return to the store every time a truck is dispatched to a region. The total time to return to the store is the round trip drive time plus the amount of deliveries made within the region multiplied times the intra-zone delivery time.

Figure 49 shows the interface for the One-Way Drive Times with two regions' times already changed to 90 minutes, with preparations for the same amount to be input into Region C4. Figure 50 shows the settings report with the One-Way Drive Times generated on the fly, and in accordance with the settings that were specified at the beginning of this simulation.

Figure 51 shows the Round Trip Times for the manually changed regions in proportion to C1 and region F10. Note that although Region C1 is in the same “concentric zone” as other “C” regions, and that Region F10 is geographically farther away from all “C” regions, both of these regions have substantially less Round Trip Drive Times.

Figure 52 shows the Population Options tab on the Simulation Options form with “250” entered into the dialogue box. Figure 53 shows the Population Per Region interface that appeared after the “Submit” button was pressed.

Population per individual region can be entered through this interface by clicking on any hexagon. This simulation gives an example of regions B1 and C2 having no households, and regions A4, A3, and B4 having 9,000 households.

Figure 54 shows all but Region B4’s population changed. Figure 54 shows the status of the population input form after region B4 was clicked on. Figure 55 shows the Main Map upon completion of this simulation. From this interface is easily seen by comparing the regions to the legend, that Region B1 and Region C1 generated no orders. In contrast, regions A4, A3, and B4 generated far greater orders than any other region.

The contrast in the amount of orders generated by all of the regions in this simulation can be seen even more clearly in the automatically-generated bar chart on the Report Dashboard (Figure 56). The Population Report for this simulation shows, both graphically and through a table, the proportionate population per region (Figure 57). Each bar shows the amount of households in the region. The y axis values are multiplied by 10. Therefore, if the y axis shows “500” for a region, the amount of households in that region is  $500 \times 10 = 5,000$  households.

The above discussion is intended to describe the various functions that are contained in the simulation software. The above also demonstrates the uniqueness of the application in that although companies such as SAP and Manugistics have developed sophisticated logistic decision making software, neither of these companies have developed anything specifically for the grocery delivery industry. In addition, the software application actually runs very well. This is not a trivial statement when considering that 650 pages of computer code, along with myriad algorithms underlie the application. The application can be run thousands of times without any faults, operational or logical, occurring. Additionally, when generating the screen shots in this section, the application ran without a single hitch, or system failure occurring.

The above sequence of simulations is intended to provide the reader with the overall scope of the logistical decision-making application that I developed. First, the application's interface (main map, drop down menus, control buttons, and radio buttons) are intended to allow decision makers to use the application with relative ease. This logistical application, despite containing sophisticated functionality, should be able to be adopted by online grocers with minimal amounts of information technology background. Indeed, many software packages contain tutorial manuals that are hundreds of pages long. If this is contrasted with the mere dozens of pages of screen shots (above) and associated written explanations, it should be evident that this application is relatively easy to use, thereby solving one of the integral problems of software application adoption by businesses – a high learning curve to use the applications.

Another very significant reason the Simulation Elucidation section is incorporated in this dissertation is to clearly demonstrate that the various reports, which essentially

constitute the grocers “logistical dashboard” are generated “on the fly,” which means that no manual data retrieval processes are needed, such as writing sophisticated SQL (structured query language) queries. This is an important point because it alleviates the need to use database personnel to retrieve information such as delivery times and profitability per region. This data is clearly shown in the reports which can be printed after simulations are run.

Also, the Simulation Elucidation should show that the application is aesthetically pleasing, which is a nice amenity to managers and operational personnel that have to use it on a daily basis. An actual grocery store can input the addresses gleaned from the surveys it had its customers’ complete into the application. The application as is exists now, has 10,000 hypothetical addresses per region in the underlying spreadsheets that are not visible to the user when the application is run. In other words, this application has 66,000 addresses that it hits upon when it runs.

A grocer who is considering an online delivery initiative would first input its customers’ addresses into the spreadsheets. Because of the ability of the application to allow the user to specify the population per individual region, when the simulation runs, the grocer will get a realistic estimate of how many orders are generated per region. When this is combined with the Mandatory Profit function, the results of each simulation, or combination of simulations, will show if those regions meet the profit requirements that the grocer needs to deliver to the regions.

One other important function that the grocer must use is the Minimum Dollar Delivery amount. This amount could be from \$0 to as high as the grocer deems feasible.

By altering the Minimum Dollar Delivery variable, along with the Mandatory Profit, and Profit Margin, the grocer can see whether the initiative may be profitable.



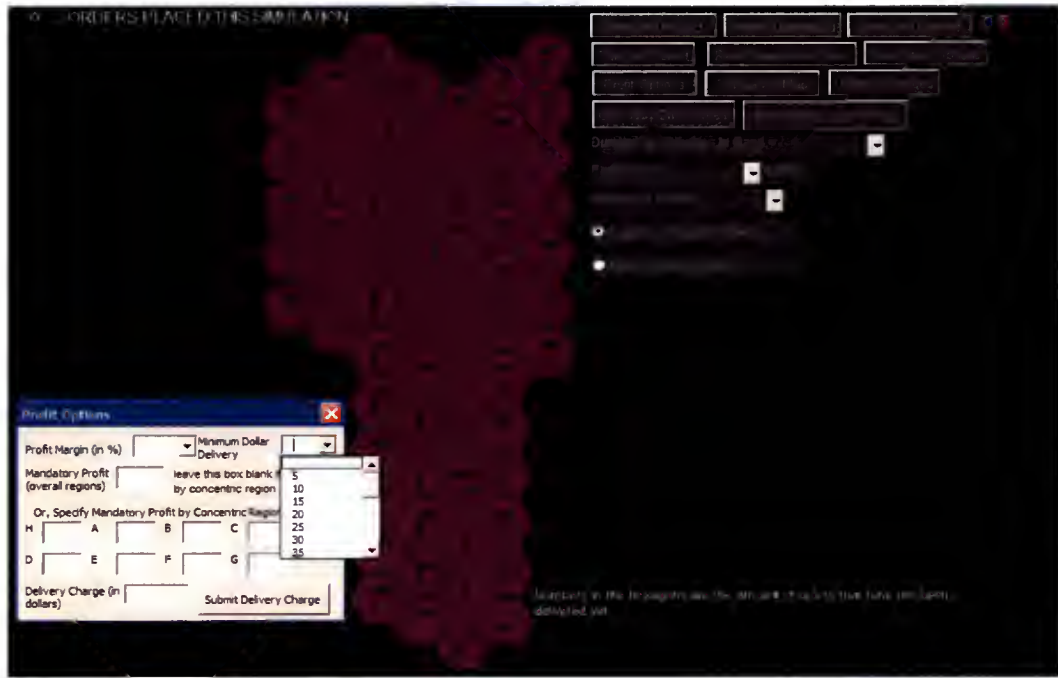


Figure 4. Minimum dollar delivery



Figure 5. Mandatory profit

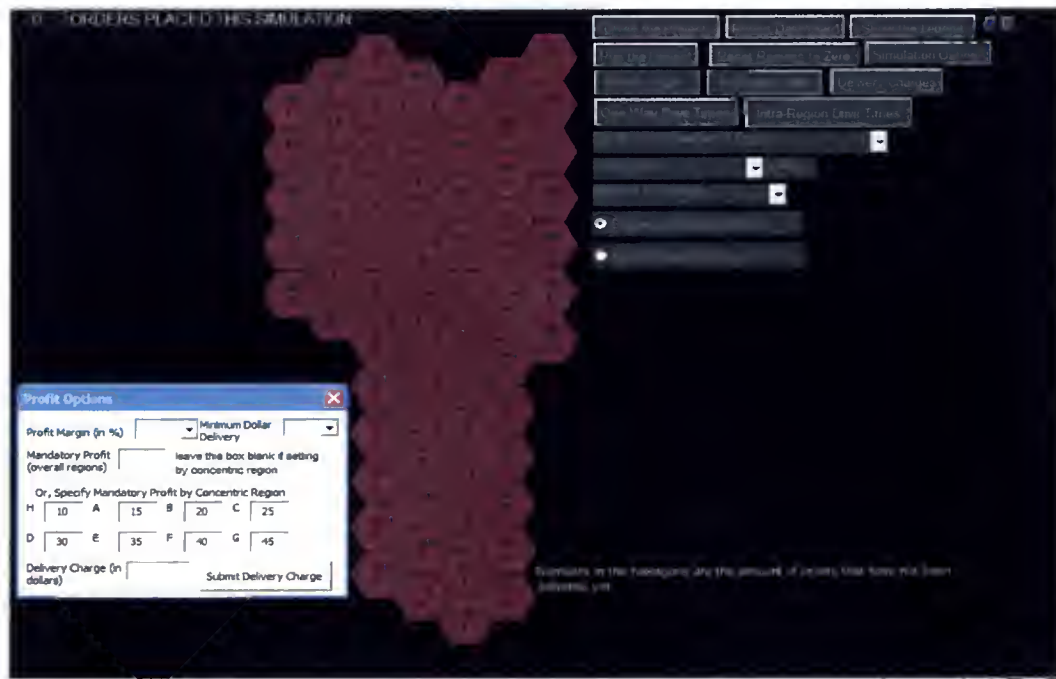


Figure 6. Delivery charge per concentric region

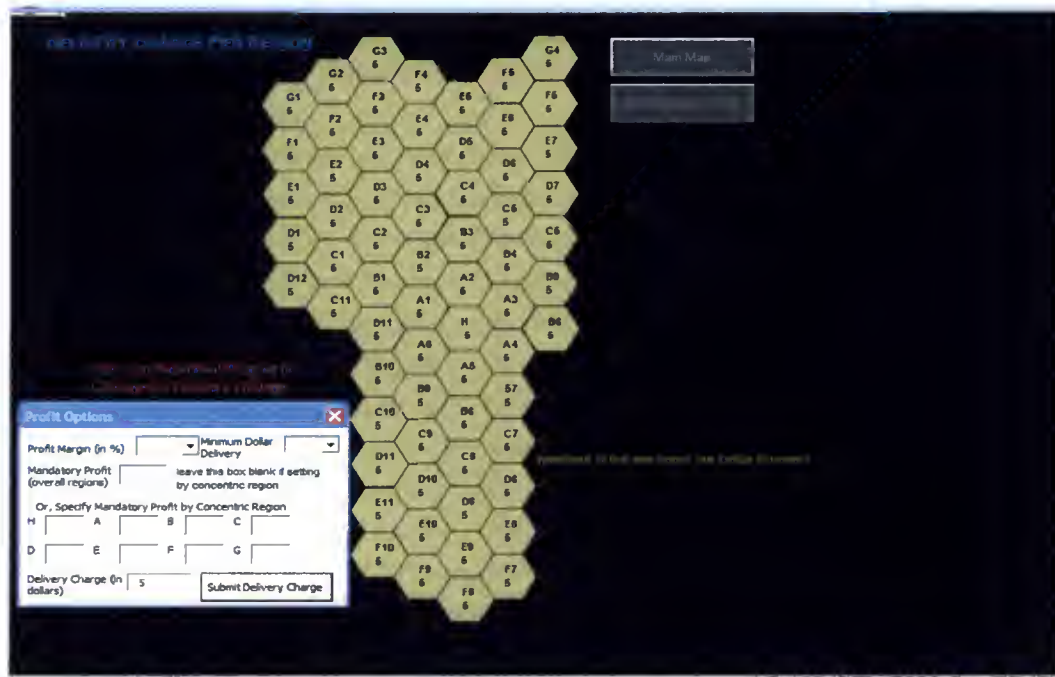


Figure 7. Delivery charge per region interface

The screenshot shows a simulation interface with a hexagonal grid map. The map is divided into regions labeled G1 through G4, F1 through F8, E1 through E8, D1 through D8, C1 through C8, B1 through B4, and A1 through A4. A red box highlights region E4. Two pop-up forms are visible:

**Delivery Charge Per Region**

Region E4 delivery charge:

**Profit Options**

Profit Margin (in %)  Minimum Dollar Delivery

Mandatory Profit (overall regions) ☐ leave this box blank & setting by concentric region

Or, Specify Mandatory Profit by Concentric Region

H  A  B  C

D  E  F  G

Delivery Charge (in dollars)

Figure 8. Delivery charge per region pop up form

The screenshot shows a simulation interface with a hexagonal grid map. The map is divided into regions labeled G1 through G4, F1 through F8, E1 through E8, D1 through D8, C1 through C8, B1 through B4, and A1 through A4. A red box highlights region E4. A pop-up form titled 'Simulation Options' is visible:

**Simulation Options**

Number of Runs  Population Options

How Many Times Would You Like to Run The Simulation?

The Simulations Will Run

☐ in the Same Time Window.

☐ in Successive (concatenated) Times.

Number of hexagons are the amount of regions that simulation (over delivered) yet.

Figure 9. Simulation options form



Figure 10. Number of orders error catching



Figure 11. Number of deliveries drop-down list

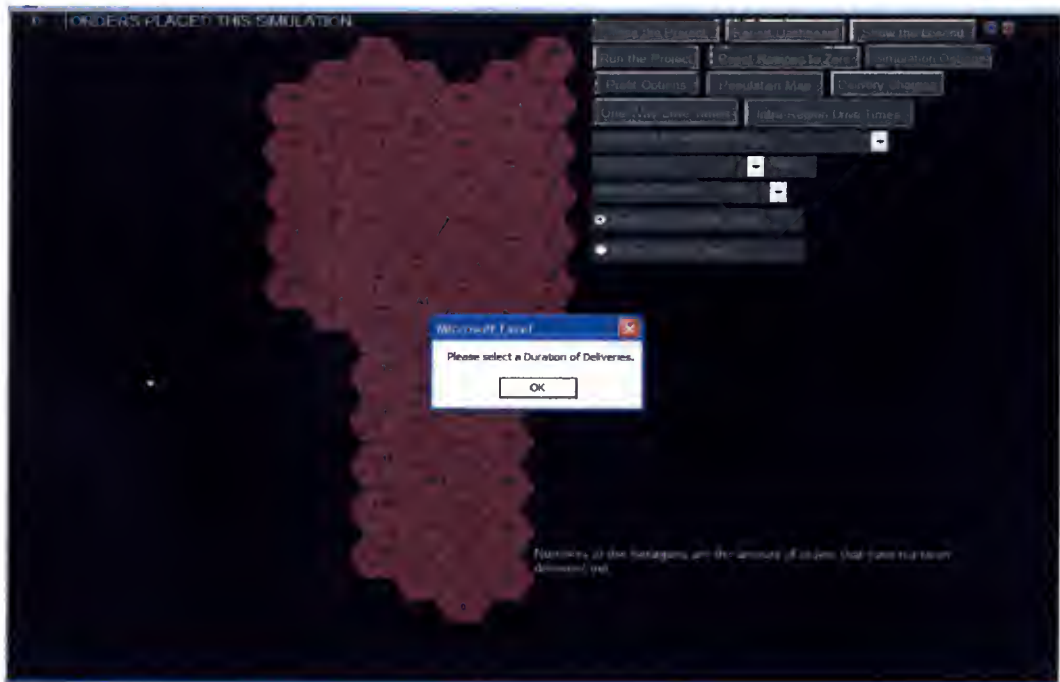


Figure 12. Duration of deliveries error catching

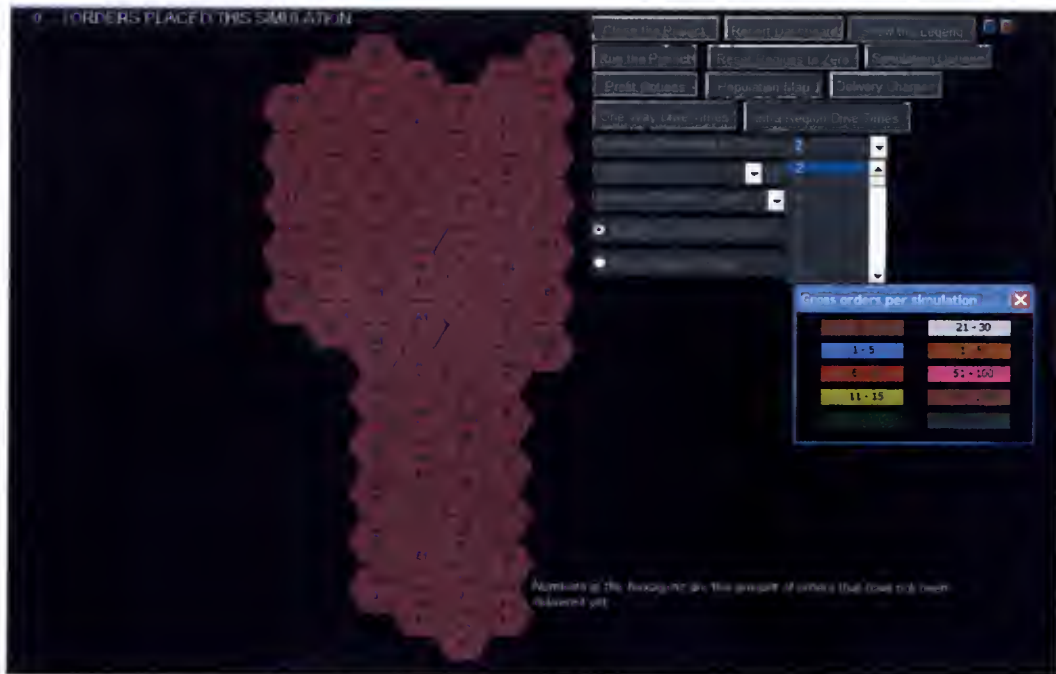


Figure 13. Duration of deliveries drop-down list

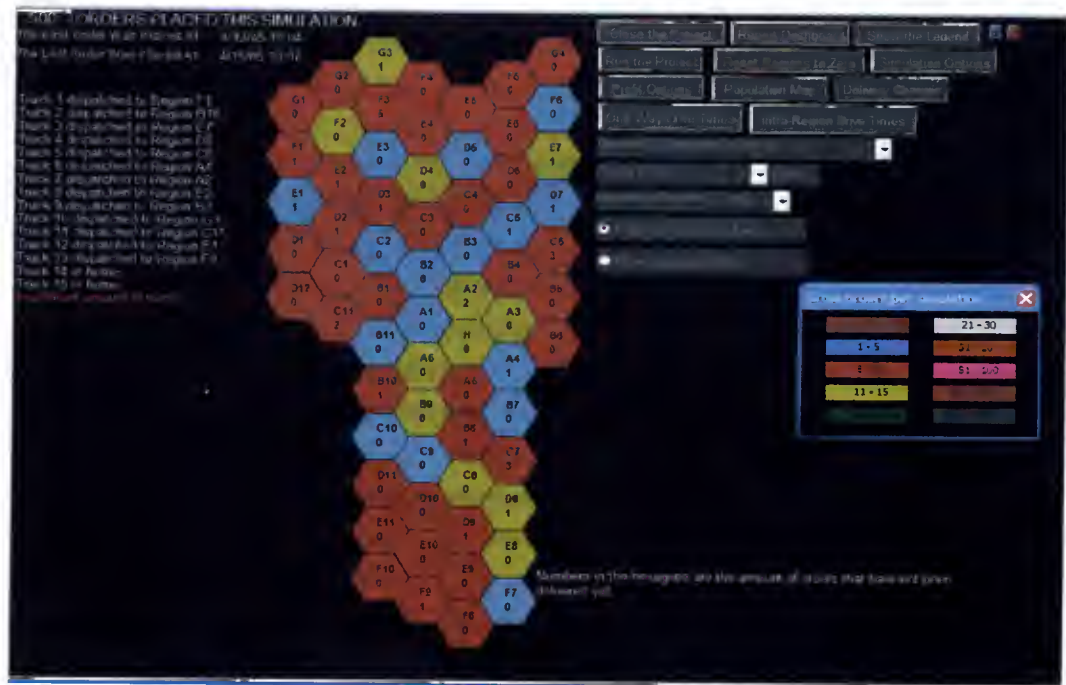


Figure 14. Region and legend color coordination

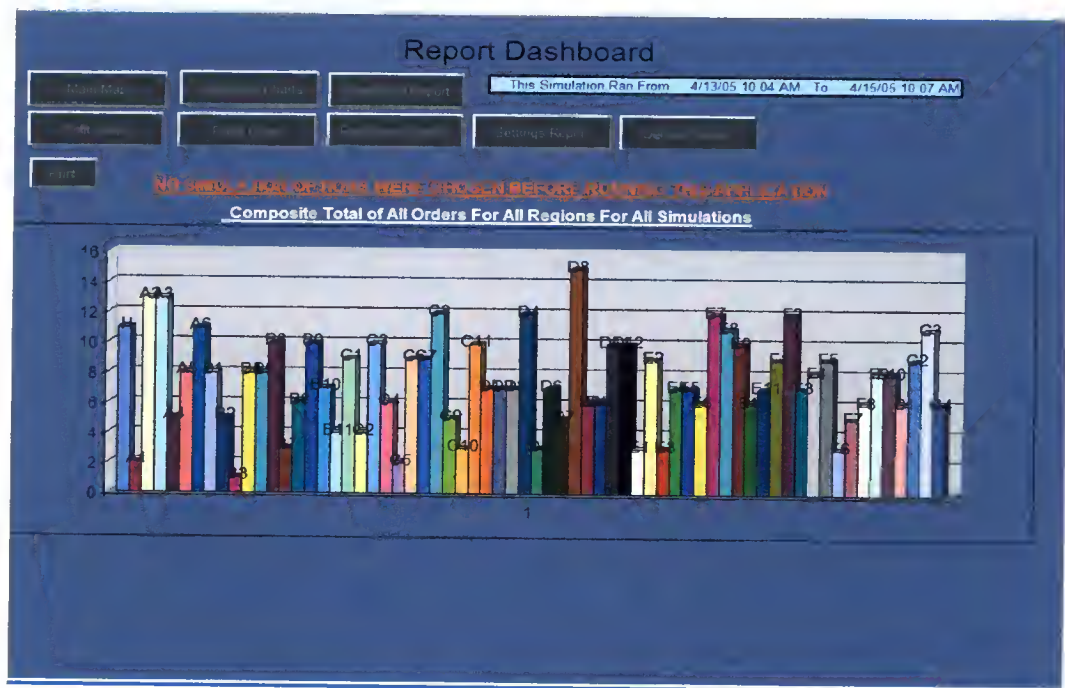


Figure 15. Report dashboard for the simulation run on April 13

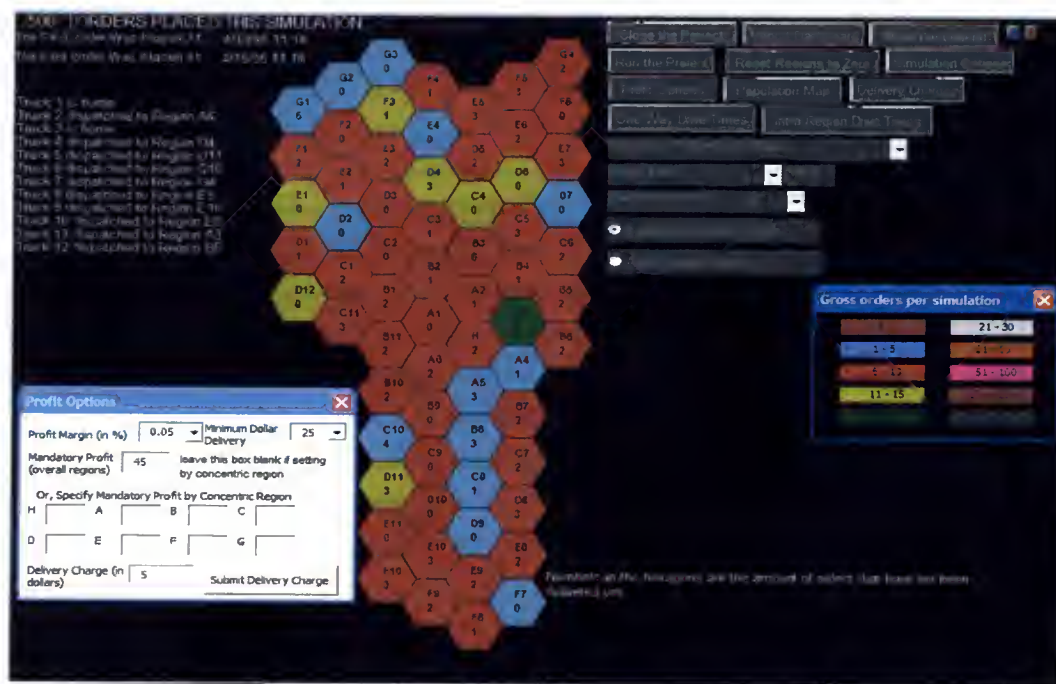


Figure 16. Simulation main map result with profit settings

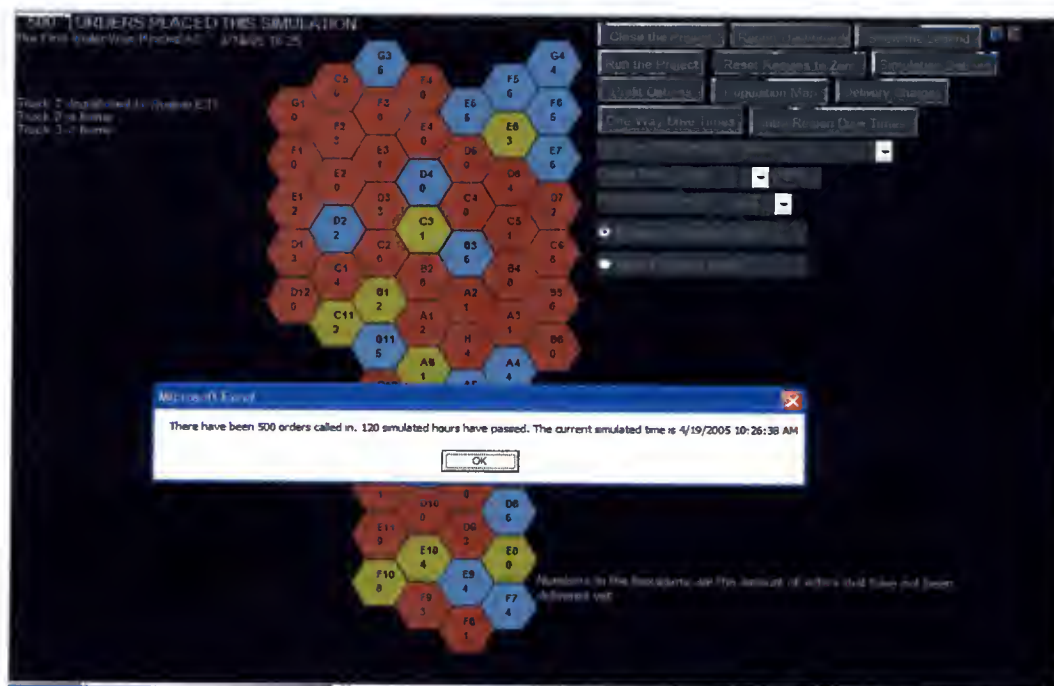
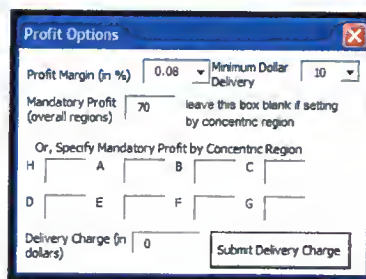


Figure 17. Pause function



**Profit Options**

Profit Margin (in %) 0.08 Minimum Dollar Delivery 10

Mandatory Profit (overall regions) 70 leave this box blank if setting by concentric region

Or, Specify Mandatory Profit by Concentric Region

H A B C

D E F G

Delivery Charge (in dollars) 0

Figure 18. Profit options form

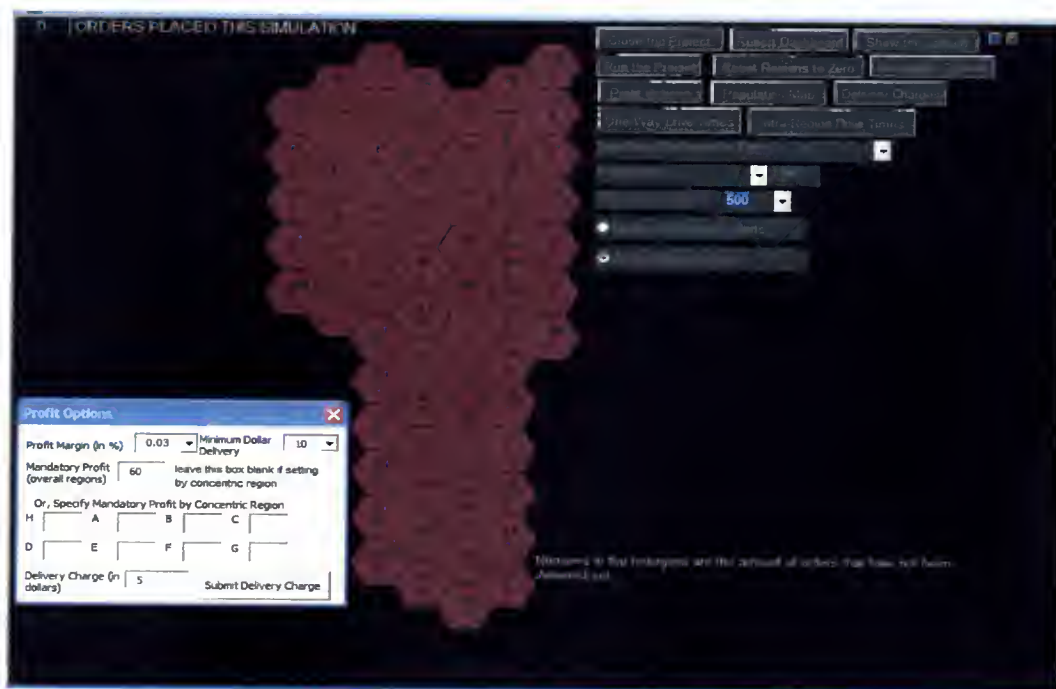


Figure 19. Allow dispatch alerts radio button

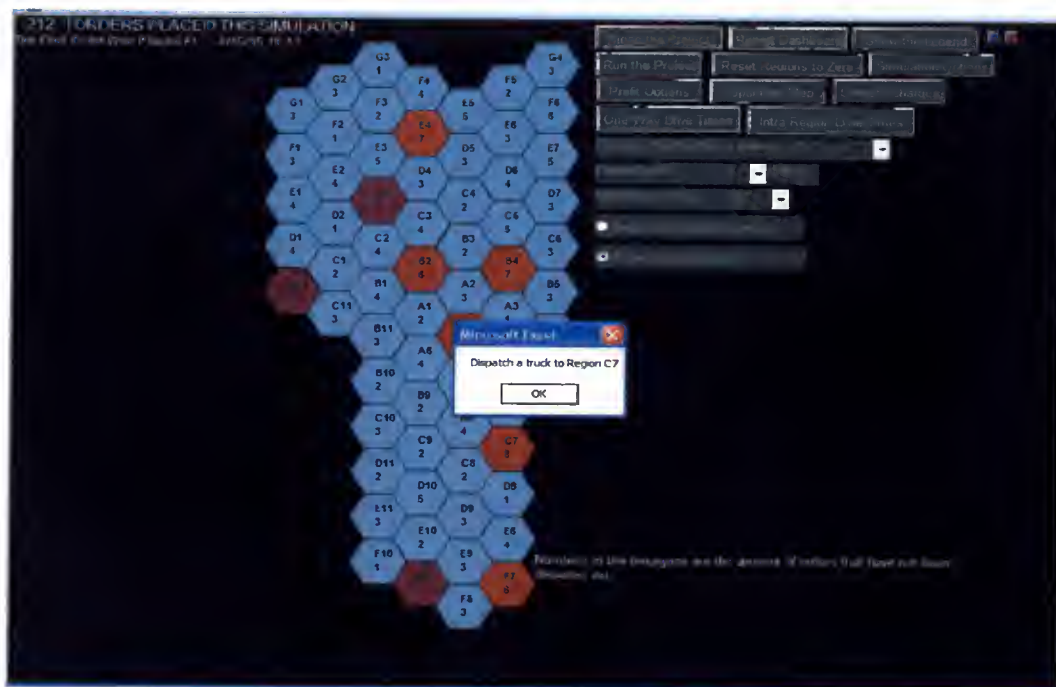


Figure 20. Truck dispatch notification

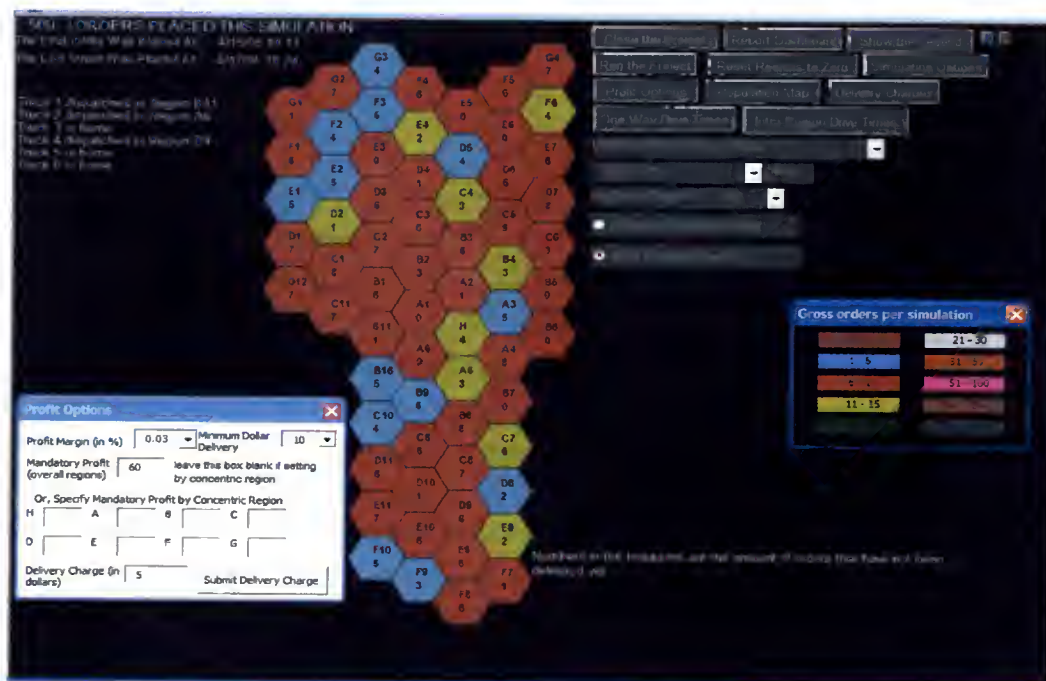


Figure 21. Simulation main map result showing truck usage

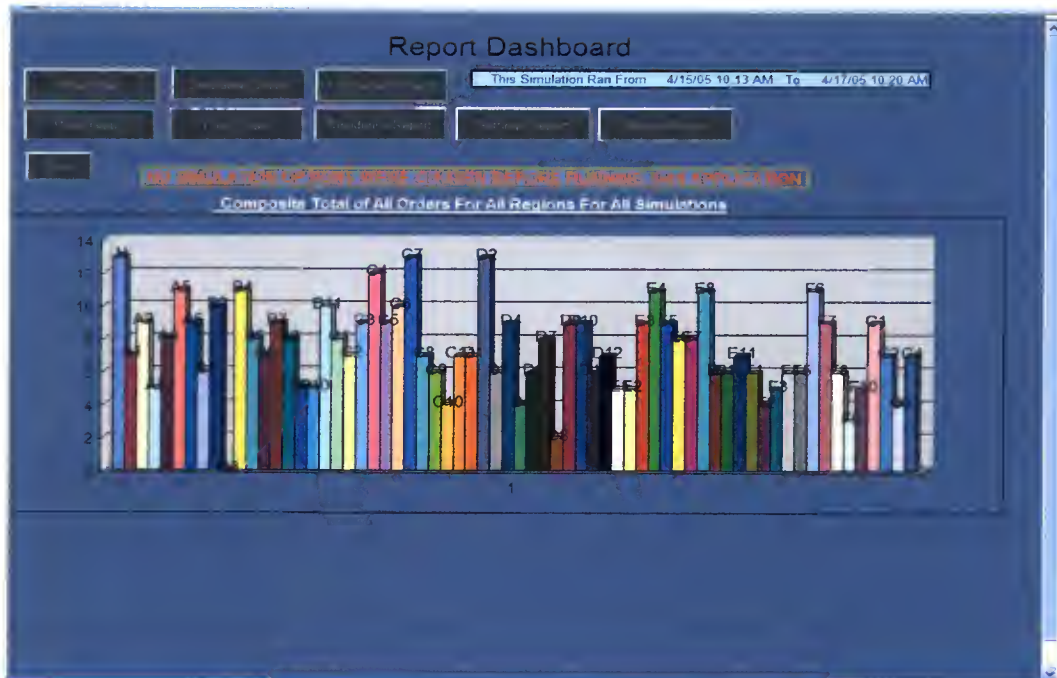


Figure 22. Report dashboard for the simulation run on April 15

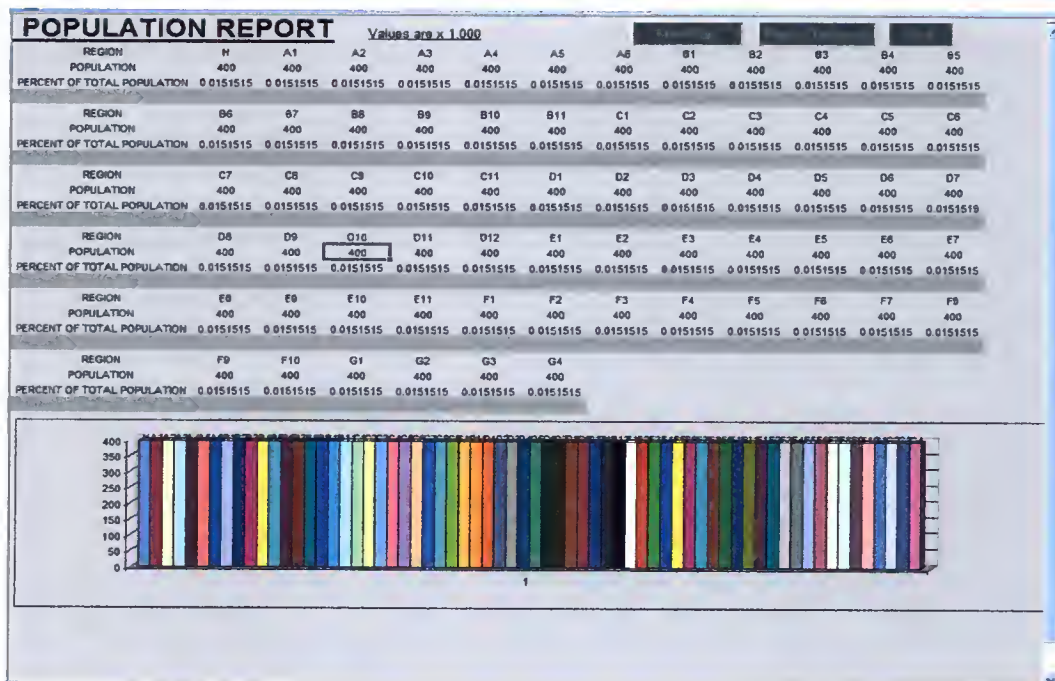


Figure 23. Population report

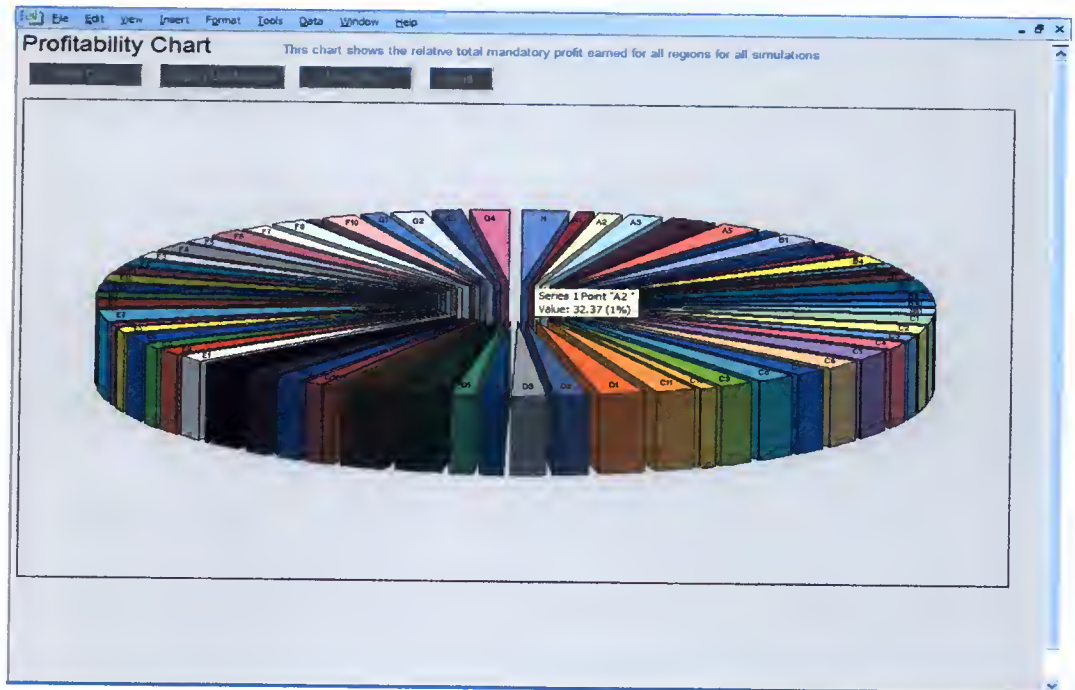


Figure 24. Profitability chart

| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |      |       |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------|-------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone | Total |
| Region H                              | 58.67        |              |              |              |              |              |              |              |              |               | H    | 58.67 |
| Region A1                             | 21.00        |              |              |              |              |              |              |              |              |               | A1   | 21.00 |
| Region A2                             | 32.37        |              |              |              |              |              |              |              |              |               | A2   | 32.37 |
| Region A3                             | 39.83        |              |              |              |              |              |              |              |              |               | A3   | 39.83 |
| Region A4                             | 59.25        |              |              |              |              |              |              |              |              |               | A4   | 59.25 |
| Region A5                             | 46.54        |              |              |              |              |              |              |              |              |               | A5   | 46.54 |
| Region A6                             | 27.00        |              |              |              |              |              |              |              |              |               | A6   | 27.00 |
| Region B1                             | 51.17        |              |              |              |              |              |              |              |              |               | B1   | 51.17 |
| Region B2                             | 44.82        |              |              |              |              |              |              |              |              |               | B2   | 44.82 |
| Region B3                             | 24.00        |              |              |              |              |              |              |              |              |               | B3   | 24.00 |
| Region B4                             | 44.47        |              |              |              |              |              |              |              |              |               | B4   | 44.47 |
| Region B5                             | 24.00        |              |              |              |              |              |              |              |              |               | B5   | 24.00 |
| Region B6                             | 21.00        |              |              |              |              |              |              |              |              |               | B6   | 21.00 |
| Region B7                             | 27.00        |              |              |              |              |              |              |              |              |               | B7   | 27.00 |
| Region B8                             | 56.32        |              |              |              |              |              |              |              |              |               | B8   | 56.32 |
| Region B9                             | 40.97        |              |              |              |              |              |              |              |              |               | B9   | 40.97 |
| Region B10                            | 31.51        |              |              |              |              |              |              |              |              |               | B10  | 31.51 |
| Region B11                            | 31.12        |              |              |              |              |              |              |              |              |               | B11  | 31.12 |
| Region C1                             | 48.24        |              |              |              |              |              |              |              |              |               | C1   | 48.24 |
| Region C2                             | 42.87        |              |              |              |              |              |              |              |              |               | C2   | 42.87 |
| Region C3                             | 27.00        |              |              |              |              |              |              |              |              |               | C3   | 27.00 |
| Region C4                             | 50.03        |              |              |              |              |              |              |              |              |               | C4   | 50.03 |
| Region C5                             | 55.86        |              |              |              |              |              |              |              |              |               | C5   | 55.86 |
| Region C6                             | 46.80        |              |              |              |              |              |              |              |              |               | C6   | 46.80 |
| Region C7                             | 45.21        |              |              |              |              |              |              |              |              |               | C7   | 45.21 |
| Region C8                             | 52.16        |              |              |              |              |              |              |              |              |               | C8   | 52.16 |
| Region C9                             | 40.85        |              |              |              |              |              |              |              |              |               | C9   | 40.85 |
| Region C10                            | 24.79        |              |              |              |              |              |              |              |              |               | C10  | 24.79 |
| Region C11                            | 51.52        |              |              |              |              |              |              |              |              |               | C11  | 51.52 |
| Region D1                             | 53.42        |              |              |              |              |              |              |              |              |               | D1   | 53.42 |
| Region D2                             | 42.88        |              |              |              |              |              |              |              |              |               | D2   | 42.88 |
| Region D3                             | 43.96        |              |              |              |              |              |              |              |              |               | D3   | 43.96 |
| Region D4                             | 32.08        |              |              |              |              |              |              |              |              |               | D4   | 32.08 |
| Region D5                             | 29.28        |              |              |              |              |              |              |              |              |               | D5   | 29.28 |
| Region D6                             | 54.48        |              |              |              |              |              |              |              |              |               | D6   | 54.48 |
| Region D7                             | 57.24        |              |              |              |              |              |              |              |              |               | D7   | 57.24 |
| Region D8                             | 15.14        |              |              |              |              |              |              |              |              |               | D8   | 15.14 |
| Region D9                             | 27.00        |              |              |              |              |              |              |              |              |               | D9   | 27.00 |
| Region D10                            | 35.12        |              |              |              |              |              |              |              |              |               | D10  | 35.12 |
| Region D11                            | 38.02        |              |              |              |              |              |              |              |              |               | D11  | 38.02 |
| Region D12                            | 51.80        |              |              |              |              |              |              |              |              |               | D12  | 51.80 |
| Region E1                             | 42.10        |              |              |              |              |              |              |              |              |               | E1   | 42.10 |
| Region E2                             | 36.73        |              |              |              |              |              |              |              |              |               | E2   | 36.73 |
| Region E3                             | 27.00        |              |              |              |              |              |              |              |              |               | E3   | 27.00 |
| Region E4                             | 44.71        |              |              |              |              |              |              |              |              |               | E4   | 44.71 |
| Region E5                             | 27.00        |              |              |              |              |              |              |              |              |               | E5   | 27.00 |
| Region E6                             | 24.00        |              |              |              |              |              |              |              |              |               | E6   | 24.00 |
| Region E7                             | 59.63        |              |              |              |              |              |              |              |              |               | E7   | 59.63 |
| Region E8                             | 45.15        |              |              |              |              |              |              |              |              |               | E8   | 45.15 |
| Region E9                             | 31.00        |              |              |              |              |              |              |              |              |               | E9   | 31.00 |
| Region E10                            | 37.88        |              |              |              |              |              |              |              |              |               | E10  | 37.88 |
| Region E11                            | 48.01        |              |              |              |              |              |              |              |              |               | E11  | 48.01 |
| Region F1                             | 32.83        |              |              |              |              |              |              |              |              |               | F1   | 32.83 |
| Region F2                             | 35.32        |              |              |              |              |              |              |              |              |               | F2   | 35.32 |
| Region F3                             | 42.10        |              |              |              |              |              |              |              |              |               | F3   | 42.10 |
| Region F4                             | 45.62        |              |              |              |              |              |              |              |              |               | F4   | 45.62 |
| Region F5                             | 39.42        |              |              |              |              |              |              |              |              |               | F5   | 39.42 |
| Region F6                             | 45.61        |              |              |              |              |              |              |              |              |               | F6   | 45.61 |
| Region F7                             | 30.22        |              |              |              |              |              |              |              |              |               | F7   | 30.22 |
| Region F8                             | 43.43        |              |              |              |              |              |              |              |              |               | F8   | 43.43 |
| Region F9                             | 19.19        |              |              |              |              |              |              |              |              |               | F9   | 19.19 |
| Region F10                            | 42.78        |              |              |              |              |              |              |              |              |               | F10  | 42.78 |
| Region G1                             | 28.00        |              |              |              |              |              |              |              |              |               | G1   | 28.00 |
| Region G2                             | 45.83        |              |              |              |              |              |              |              |              |               | G2   | 45.83 |
| Region G3                             | 31.17        |              |              |              |              |              |              |              |              |               | G3   | 31.17 |
| Region G4                             | 53.25        |              |              |              |              |              |              |              |              |               | G4   | 53.25 |
| Total                                 | 2807.24      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Maximum                               | 59.83        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Minimum                               | 15.14        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Average                               | 39.50        |              |              |              |              |              |              |              |              |               |      |       |
| Standard Deviation                    | 11.34        |              |              |              |              |              |              |              |              |               |      |       |
| Mode                                  | 27.00        |              |              |              |              |              |              |              |              |               |      |       |
| Median                                | 41.53        |              |              |              |              |              |              |              |              |               |      |       |
| Profitability Quotient                | 5.21         |              |              |              |              |              |              |              |              |               |      |       |

Figure 25. Mandatory profit per simulation report

| Residence Report |                 |               |                      |       |           |
|------------------|-----------------|---------------|----------------------|-------|-----------|
| Simulation #     | Delivery Amount | Delivery Time | Address              | Run # | Region    |
| simulation1      | 201.76          | 4/16/05 11:05 | 302 Orange Lane      | 1     | Region A1 |
| simulation1      | 213.62          | 4/17/05 4:11  | 705 Orange Lane      | 1     | Region A1 |
| simulation1      | 60.86           | 4/17/05 2:27  | 897 Orange Lane      | 1     | Region A1 |
| simulation1      | 73.62           | 4/16/05 22:37 | 174 Grapefruit Lane  | 1     | Region A1 |
| simulation1      | 273.81          | 4/15/05 17:31 | 696 Kiwi Lane        | 1     | Region A1 |
| simulation1      | 270.01          | 4/17/05 1:35  | 359 Grape Boulevard  | 1     | Region A1 |
| simulation1      | 296.92          | 4/15/05 16:22 | 900 Grape Boulevard  | 1     | Region A1 |
| simulation1      | 63.51           | 4/17/05 5:14  | 547 Joe Boulevard    | 1     | Region A3 |
| simulation1      | 209.13          | 4/16/05 14:27 | 839 Joe Boulevard    | 1     | Region A3 |
| simulation1      | 210.61          | 4/16/05 8:18  | 860 Joe Boulevard    | 1     | Region A3 |
| simulation1      | 161.05          | 4/16/05 8:53  | 204 Pete Boulevard   | 1     | Region A3 |
| simulation1      | 183.34          | 4/15/05 23:22 | 372 Pete Boulevard   | 1     | Region A3 |
| simulation1      | 289.03          | 4/17/05 8:02  | 640 Francis Way      | 1     | Region A4 |
| simulation1      | 129.67          | 4/15/05 19:43 | 874 Francis Way      | 1     | Region A4 |
| simulation1      | 275.84          | 4/16/05 15:48 | 618 Sally Way        | 1     | Region A4 |
| simulation1      | 103.41          | 4/16/05 2:32  | 848 Sally Way        | 1     | Region A4 |
| simulation1      | 12.68           | 4/17/05 1:58  | 240 Jennifer Street  | 1     | Region A4 |
| simulation1      | 155.38          | 4/15/05 19:26 | 423 Jennifer Street  | 1     | Region A4 |
| simulation1      | 46.42           | 4/16/05 18:12 | 570 Jennifer Street  | 1     | Region A4 |
| simulation1      | 162.53          | 4/16/05 18:06 | 692 Jennifer Street  | 1     | Region A4 |
| simulation1      | 196.15          | 4/15/05 10:42 | 193 Nutmeg Road      | 1     | Region A6 |
| simulation1      | 152.81          | 4/16/05 11:57 | 623 Nutmeg Road      | 1     | Region A6 |
| simulation1      | 64.84           | 4/17/05 0:49  | 642 Nutmeg Road      | 1     | Region A6 |
| simulation1      | 161.65          | 4/15/05 20:12 | 878 Nutmeg Road      | 1     | Region A6 |
| simulation1      | 82.44           | 4/17/05 10:14 | 22 Pepper Road       | 1     | Region A6 |
| simulation1      | 246.95          | 4/16/05 22:25 | 847 Pepper Road      | 1     | Region A6 |
| simulation1      | 73.01           | 4/16/05 4:45  | 18 Salt Road         | 1     | Region A6 |
| simulation1      | 218.19          | 4/15/05 20:35 | 399 Sugar Parkway    | 1     | Region A6 |
| simulation1      | 25.78           | 4/17/05 6:01  | 862 Sugar Parkway    | 1     | Region A6 |
| simulation1      | 198.16          | 4/15/05 11:16 | 246 Seattle Street   | 1     | Region B1 |
| simulation1      | 173.79          | 4/15/05 14:03 | 106 Miami Street     | 1     | Region B1 |
| simulation1      | 32.80           | 4/16/05 12:03 | 321 Miami Street     | 1     | Region B1 |
| simulation1      | 294.74          | 4/17/05 6:24  | 572 Miami Street     | 1     | Region B1 |
| simulation1      | 115.38          | 4/15/05 20:24 | 12 Austin Street     | 1     | Region B1 |
| simulation1      | 290.70          | 4/15/05 18:34 | 302 Austin Street    | 1     | Region B1 |
| simulation1      | 273.74          | 4/17/05 5:49  | 197 White Boulevard  | 2     | Region B2 |
| simulation1      | 221.09          | 4/16/05 4:51  | 568 White Boulevard  | 1     | Region B2 |
| simulation1      | 187.85          | 4/16/05 2:15  | 624 White Boulevard  | 1     | Region B2 |
| simulation1      | 223.25          | 4/15/05 10:13 | 393 Red Boulevard    | 1     | Region B2 |
| simulation1      | 202.23          | 4/16/05 23:52 | 290 Blue Boulevard   | 2     | Region B2 |
| simulation1      | 241.49          | 4/15/05 17:48 | 727 Blue Boulevard   | 1     | Region B2 |
| simulation1      | 277.32          | 4/15/05 15:59 | 947 Blue Boulevard   | 1     | Region B2 |
| simulation1      | 228.22          | 4/16/05 13:12 | 57 Yellow Parkway    | 1     | Region B2 |
| simulation1      | 11.47           | 4/17/05 7:15  | 394 Yellow Parkway   | 2     | Region B2 |
| simulation1      | 153.79          | 4/15/05 21:27 | 812 Yellow Parkway   | 1     | Region B2 |
| simulation1      | 22.35           | 4/16/05 20:18 | 368 Rose Avenue      | 2     | Region B4 |
| simulation1      | 278.93          | 4/16/05 9:10  | 476 Rose Avenue      | 1     | Region B4 |
| simulation1      | 197.78          | 4/17/05 9:40  | 520 Rose Avenue      | 2     | Region B4 |
| simulation1      | 119.57          | 4/16/05 5:19  | 154 Tulip Avenue     | 1     | Region B4 |
| simulation1      | 96.90           | 4/15/05 13:35 | 424 Tulip Avenue     | 1     | Region B4 |
| simulation1      | 286.20          | 4/15/05 19:20 | 77 Pansy Avenue      | 1     | Region B4 |
| simulation1      | 134.52          | 4/15/05 16:56 | 592 Pansy Avenue     | 1     | Region B4 |
| simulation1      | 147.66          | 4/15/05 10:53 | 602 Pansy Avenue     | 1     | Region B4 |
| simulation1      | 259.21          | 4/15/05 18:46 | 211 Sunflower Avenue | 1     | Region B4 |
| simulation1      | 163.94          | 4/15/05 10:19 | 268 Sunflower Avenue | 1     | Region B4 |
| simulation1      | 162.26          | 4/16/05 22:54 | 827 Sunflower Avenue | 2     | Region B4 |
| simulation1      | 76.06           | 4/16/05 11:17 | 549 Owl Lane         | 1     | Region B5 |
| simulation1      | 122.10          | 4/16/05 9:22  | 701 Owl Lane         | 1     | Region B5 |
| simulation1      | 224.64          | 4/17/05 0:09  | 983 Owl Lane         | 1     | Region B5 |
| simulation1      | 291.89          | 4/16/05 8:30  | 53 Sparrow Lane      | 1     | Region B5 |
| simulation1      | 150.64          | 4/15/05 12:08 | 370 Sparrow Lane     | 1     | Region B5 |

Figure 26. Residence report

### Settings Report

|                                     |      |                          |     |
|-------------------------------------|------|--------------------------|-----|
| Number of Simulations:              | 1    | Suppress Dispatch Alerts | No  |
| Duration of Deliveries in Days:     | 2    | Allow Dispatch Alerts    | Yes |
| Simulation Times are Concatenated:  | Yes  |                          |     |
| Simulations Occur at the Same Time: | No   |                          |     |
| Profit Margin (in percent)          | 0.03 |                          |     |
| Minimum Dollar Delivery             | 10   |                          |     |
| Number of Orders per Simulation:    | 500  |                          |     |

| Region     | Population x 10 | Delivery Charge | One-Way Drive Time | Intra-Regional Drive Time | Mandatory Profit | Region     |
|------------|-----------------|-----------------|--------------------|---------------------------|------------------|------------|
| Region H   | 400             | 5.00            | 10                 | 5.00                      | 60               | Region H   |
| Region A1  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A1  |
| Region A2  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A2  |
| Region A3  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A3  |
| Region A4  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A4  |
| Region A5  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A5  |
| Region A6  | 400             | 5.00            | 15                 | 5.00                      | 60               | Region A6  |
| Region B1  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B1  |
| Region B2  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B2  |
| Region B3  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B3  |
| Region B4  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B4  |
| Region B5  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B5  |
| Region B6  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B6  |
| Region B7  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B7  |
| Region B8  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B8  |
| Region B9  | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B9  |
| Region B10 | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B10 |
| Region B11 | 400             | 5.00            | 20                 | 5.00                      | 60               | Region B11 |
| Region C1  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C1  |
| Region C2  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C2  |
| Region C3  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C3  |
| Region C4  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C4  |
| Region C5  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C5  |
| Region C6  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C6  |
| Region C7  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C7  |
| Region C8  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C8  |
| Region C9  | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C9  |
| Region C10 | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C10 |
| Region C11 | 400             | 5.00            | 25                 | 5.00                      | 60               | Region C11 |
| Region D1  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D1  |
| Region D2  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D2  |
| Region D3  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D3  |
| Region D4  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D4  |
| Region D5  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D5  |
| Region D6  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D6  |
| Region D7  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D7  |
| Region D8  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D8  |
| Region D9  | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D9  |
| Region D10 | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D10 |
| Region D11 | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D11 |
| Region D12 | 400             | 5.00            | 30                 | 5.00                      | 60               | Region D12 |
| Region E1  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E1  |
| Region E2  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E2  |
| Region E3  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E3  |
| Region E4  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E4  |
| Region E5  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E5  |
| Region E6  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E6  |
| Region E7  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E7  |
| Region E8  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E8  |
| Region E9  | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E9  |
| Region E10 | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E10 |
| Region E11 | 400             | 5.00            | 35                 | 5.00                      | 60               | Region E11 |
| Region F1  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F1  |
| Region F2  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F2  |
| Region F3  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F3  |
| Region F4  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F4  |
| Region F5  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F5  |
| Region F6  | 400             | 5.00            | 40                 | 5.00                      | 60               | Region F6  |

Figure 27. Settings report

| Delivery Report |                                  |               |               |                 |                       |                  |
|-----------------|----------------------------------|---------------|---------------|-----------------|-----------------------|------------------|
| Report Summary  |                                  |               |               |                 |                       |                  |
| Main Map        |                                  |               |               |                 |                       |                  |
| Print           |                                  |               |               |                 |                       |                  |
| Simulation #    | Truck and Region                 | Sent Time     | Return Time   | Round Trip Time | Gross Regional Profit | Mandatory Profit |
| Simulation 1    | Truck 1 dispatched to Region D3  | 4/17/05 10:00 | 4/17/05 11:38 | 1:37            | \$62.07               | \$2.07           |
| Simulation 1    | Truck 1 dispatched to Region D6  | 4/17/05 14:07 | 4/17/05 15:51 | 1:43            | \$69.09               | \$9.09           |
| Simulation 1    | Truck 1 dispatched to Region H   | 4/17/05 15:51 | 4/17/05 16:55 | 1:03            | \$64.41               | \$4.41           |
| Simulation 1    | Truck 2 dispatched to Region B7  | 4/17/05 16:14 | 4/17/05 17:35 | 1:20            | \$62.28               | \$2.28           |
| Simulation 1    | Truck 1 dispatched to Region A6  | 4/17/05 20:16 | 4/17/05 21:20 | 1:03            | \$61.48               | \$1.48           |
| Simulation 1    | Truck 2 dispatched to Region D2  | 4/17/05 20:28 | 4/17/05 22:11 | 1:43            | \$64.90               | \$4.90           |
| Simulation 1    | Truck 3 dispatched to Region E8  | 4/17/05 20:45 | 4/17/05 22:35 | 1:49            | \$60.81               | \$0.81           |
| Simulation 1    | Truck 1 dispatched to Region E6  | 4/17/05 22:29 | 4/18/05 0:16  | 1:49            | \$60.70               | \$0.70           |
| Simulation 1    | Truck 2 dispatched to Region B10 | 4/17/05 22:40 | 4/18/05 0:01  | 1:20            | \$67.21               | \$7.21           |
| Simulation 1    | Truck 3 dispatched to Region D1  | 4/17/05 22:58 | 4/18/05 0:36  | 1:37            | \$63.71               | \$3.71           |
| Simulation 1    | Truck 4 dispatched to Region F8  | 4/17/05 23:21 | 4/18/05 1:27  | 2:06            | \$61.80               | \$1.80           |
| Simulation 1    | Truck 1 dispatched to Region C2  | 4/18/05 0:24  | 4/18/05 1:56  | 1:32            | \$68.12               | \$8.12           |
| Simulation 1    | Truck 2 dispatched to Region E1  | 4/18/05 1:16  | 4/18/05 3:11  | 1:55            | \$61.80               | \$1.80           |
| Simulation 1    | Truck 3 dispatched to Region A4  | 4/18/05 1:45  | 4/18/05 3:00  | 1:14            | \$66.03               | \$6.03           |
| Simulation 1    | Truck 4 dispatched to Region E9  | 4/18/05 1:51  | 4/18/05 3:46  | 1:55            | \$65.41               | \$5.41           |
| Simulation 1    | Truck 1 dispatched to Region G4  | 4/18/05 2:14  | 4/18/05 4:26  | 2:12            | \$61.52               | \$1.52           |
| Simulation 1    | Truck 1 dispatched to Region H   | 4/18/05 5:53  | 4/18/05 7:19  | 1:26            | \$63.61               | \$3.61           |
| Simulation 1    | Truck 1 dispatched to Region C1  | 4/18/05 7:25  | 4/18/05 8:51  | 1:26            | \$62.82               | \$2.82           |
| Simulation 1    | Truck 2 dispatched to Region A5  | 4/18/05 7:31  | 4/18/05 8:45  | 1:14            | \$64.42               | \$4.42           |
| Simulation 1    | Truck 2 dispatched to Region G3  | 4/18/05 8:45  | 4/18/05 11:10 | 2:24            | \$63.19               | \$3.19           |
| Simulation 1    | Truck 1 dispatched to Region C3  | 4/18/05 9:55  | 4/18/05 11:38 | 1:43            | \$63.63               | \$3.63           |
| Simulation 1    | Truck 3 dispatched to Region B9  | 4/18/05 10:06 | 4/18/05 11:27 | 1:20            | \$71.38               | \$11.38          |
| Simulation 1    | Truck 4 dispatched to Region A1  | 4/18/05 10:12 | 4/18/05 11:33 | 1:20            | \$68.64               | \$8.64           |
| Simulation 1    | Truck 5 dispatched to Region C4  | 4/18/05 10:23 | 4/18/05 11:58 | 1:32            | \$64.39               | \$4.38           |
| Simulation 1    | Truck 1 dispatched to Region D6  | 4/18/05 12:01 | 4/18/05 14:06 | 2:06            | \$63.04               | \$3.04           |

Figure 28. Delivery report

0 - ORDERS PLACED THIS SIMULATION

Simulation # 1

Close this report | Adjust simulation | Show the settings

Run this report | Set of Regions to Z | Simulation Map

Get all items | Simulation Map | Simulation Map

Get every day times | Add region active times

Simulation Options

Number of Runs | Population Options

How Many Times Would You Like to Run The Simulation?

3

The Simulations Will Run

☐ in the Same Time Window.

☒ in Successive (concatenated) Times.

Profit Options

Profit Margin (in %) 0.02 Minimum Dollar Delivery 35

Mandatory Profit (overall regions) 50 leave this box blank if setting by concentric region

Or, Specify Mandatory Profit by Concentric Region

H ☐ A ☐ B ☐ C ☐

D ☐ E ☐ F ☐ G ☐

Delivery Charge (in dollars) 10 Submit Delivery Charge

Numbers in the background are the amount of orders that have not been delivered yet

Figure 29. Simulation options form

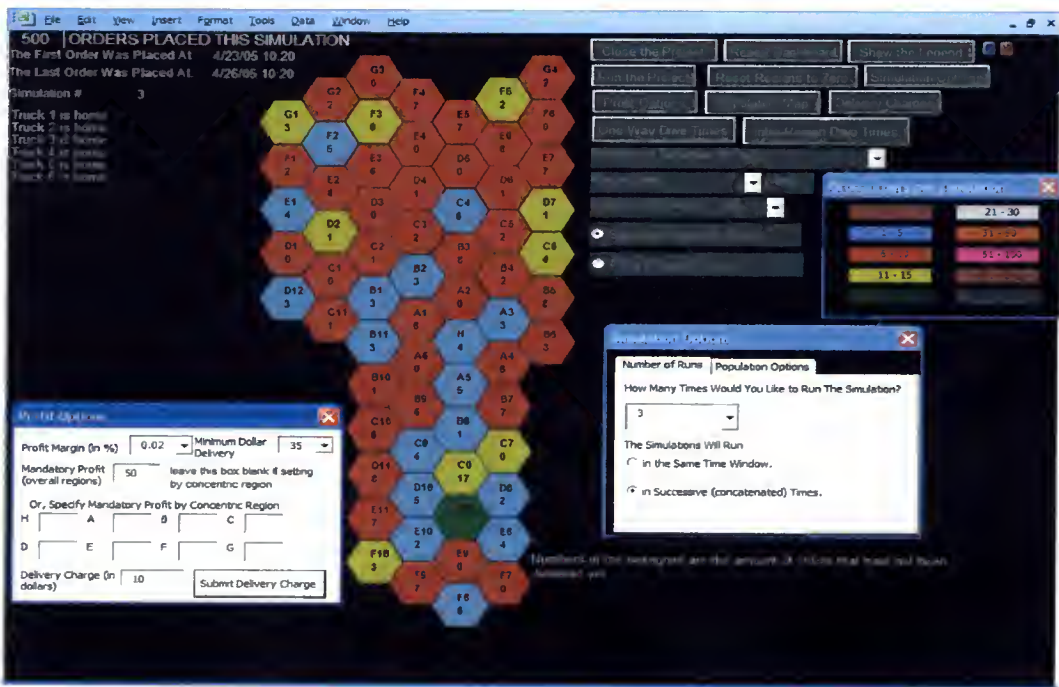


Figure 30. Simulation main map result showing three simulations



Figure 31. Simulation charts report

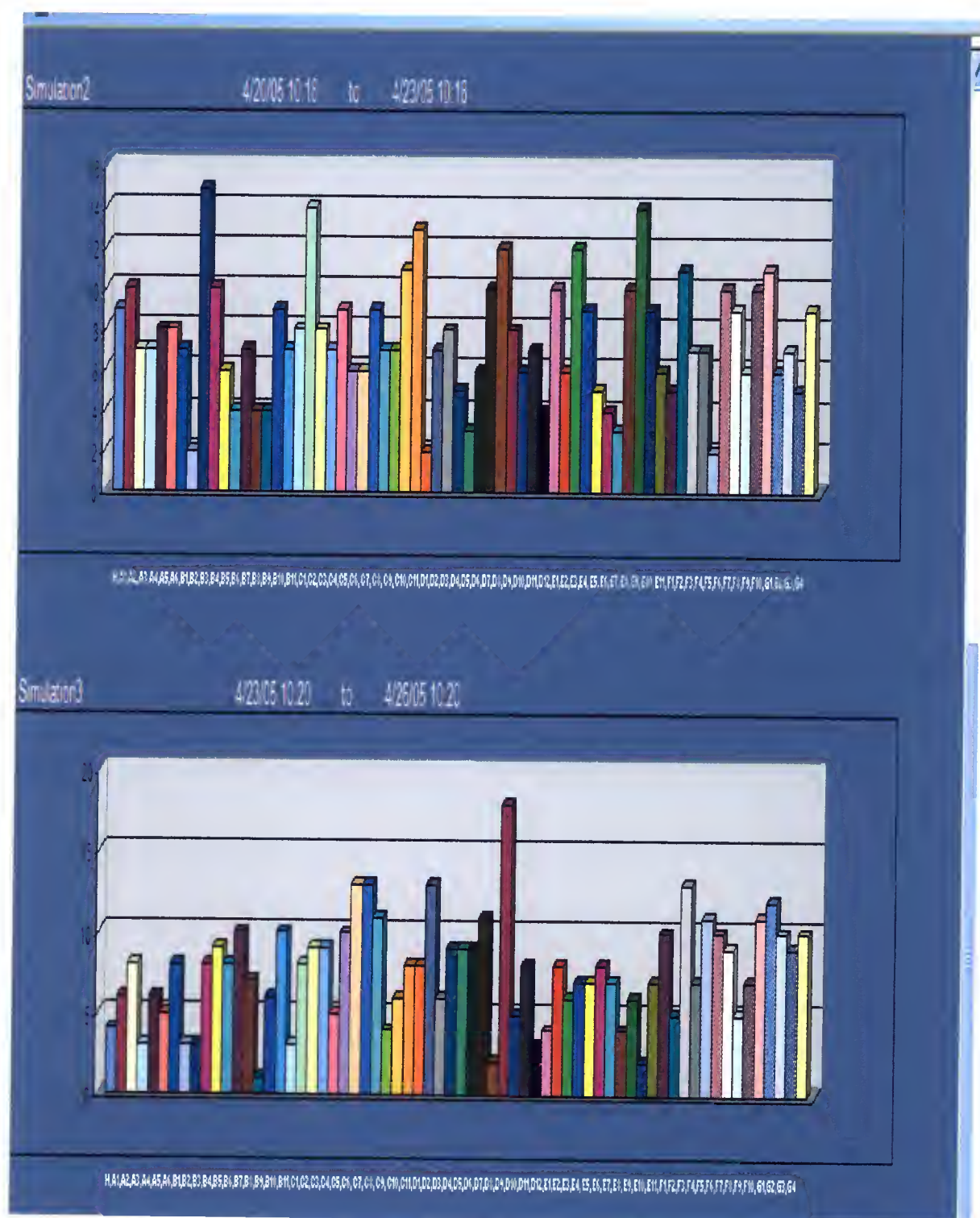


Figure 32. Simulation charts report showing second and third simulation

| Settings Report                    |      |                          |     |
|------------------------------------|------|--------------------------|-----|
| Number of Simulations              | 3    | Suppress Dispatch Alerts | Yes |
| Duration of Deliveries in Days     | 3    | Allow Dispatch Alerts    | No  |
| Simulation Times are Concatenated  | Yes  |                          |     |
| Simulations Occur at the Same Time | No   |                          |     |
| Profit Margin (in percent)         | 0.02 |                          |     |
| Minimum Dollar Delivery            | 35   |                          |     |
| Number of Orders per Simulation    | 500  |                          |     |

Figure 33. Settings report showing three simulations

| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |            |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone Total |
| Region H                              | 28.08        | 35.35        | 26.37        |              |              |              |              |              |              |               | H 89.80    |
| Region A1                             | 25.19        | 48.22        | 48.08        |              |              |              |              |              |              |               | A1 105.39  |
| Region A2                             | 36.37        | 48.44        | 24.00        |              |              |              |              |              |              |               | A2 108.41  |
| Region A3                             | 21.00        | 44.75        | 19.90        |              |              |              |              |              |              |               | A3 85.66   |
| Region A4                             | 24.00        | 48.19        | 37.23        |              |              |              |              |              |              |               | A4 109.39  |
| Region A5                             | 47.60        | 24.00        | 30.27        |              |              |              |              |              |              |               | A5 101.88  |
| Region A6                             | 27.00        | 40.82        | 24.00        |              |              |              |              |              |              |               | A6 91.82   |
| Region B1                             | 22.05        | 11.45        | 10.97        |              |              |              |              |              |              |               | B1 52.47   |
| Region B2                             | 33.49        | 45.00        | 23.13        |              |              |              |              |              |              |               | B2 101.62  |
| Region B3                             | 25.47        | 30.00        | 30.01        |              |              |              |              |              |              |               | B3 85.48   |
| Region B4                             | 29.69        | 44.12        | 36.46        |              |              |              |              |              |              |               | B4 110.27  |
| Region B6                             | 24.00        | 25.37        | 45.57        |              |              |              |              |              |              |               | B6 94.94   |
| Region B6                             | 17.59        | 48.35        | 40.30        |              |              |              |              |              |              |               | B6 104.24  |
| Region B7                             | 46.21        | 26.93        | 48.33        |              |              |              |              |              |              |               | B7 119.47  |
| Region B8                             | 19.67        | 23.89        | 6.81         |              |              |              |              |              |              |               | B8 48.56   |
| Region B9                             | 27.35        | 29.51        | 39.91        |              |              |              |              |              |              |               | B9 96.77   |
| Region B10                            | 33.07        | 46.14        | 31.77        |              |              |              |              |              |              |               | B10 110.98 |
| Region B11                            | 45.43        | 48.15        | 18.74        |              |              |              |              |              |              |               | B11 112.31 |
| Region C1                             | 43.75        | 42.00        | 24.00        |              |              |              |              |              |              |               | C1 109.75  |
| Region C2                             | 37.41        | 45.48        | 32.29        |              |              |              |              |              |              |               | C2 115.18  |
| Region C3                             | 35.52        | 36.07        | 31.99        |              |              |              |              |              |              |               | C3 106.59  |
| Region C4                             | 35.09        | 36.19        | 31.95        |              |              |              |              |              |              |               | C4 103.22  |
| Region C5                             | 32.94        | 39.06        | 37.11        |              |              |              |              |              |              |               | C5 109.12  |
| Region C6                             | 27.90        | 39.28        | 49.69        |              |              |              |              |              |              |               | C6 116.88  |
| Region C7                             | 41.87        | 31.43        | 39.00        |              |              |              |              |              |              |               | C7 112.09  |
| Region C8                             | 42.00        | 39.83        | 42.52        |              |              |              |              |              |              |               | C8 124.15  |
| Region C9                             | 28.19        | 21.00        | 36.67        |              |              |              |              |              |              |               | C9 85.86   |
| Region C10                            | 40.04        | 46.01        | 40.64        |              |              |              |              |              |              |               | C10 126.69 |
| Region C11                            | 15.42        | 39.00        | 27.89        |              |              |              |              |              |              |               | C11 82.31  |
| Region D1                             | 47.10        | 12.29        | 24.00        |              |              |              |              |              |              |               | D1 83.39   |
| Region D2                             | 43.78        | 44.01        | 48.70        |              |              |              |              |              |              |               | D2 128.49  |
| Region D3                             | 40.62        | 24.00        | 46.40        |              |              |              |              |              |              |               | D3 111.02  |
| Region D4                             | 37.75        | 32.95        | 28.54        |              |              |              |              |              |              |               | D4 98.24   |
| Region D6                             | 24.00        | 21.09        | 27.00        |              |              |              |              |              |              |               | D6 72.08   |
| Region D6                             | 27.00        | 39.24        | 28.48        |              |              |              |              |              |              |               | D6 94.72   |
| Region D7                             | 37.09        | 30.00        | 38.46        |              |              |              |              |              |              |               | D7 105.57  |
| Region D8                             | 27.00        | 46.19        | 8.77         |              |              |              |              |              |              |               | D8 82.95   |
| Region D9                             | 39.85        | 49.19        | 54.00        |              |              |              |              |              |              |               | D9 142.03  |
| Region D10                            | 24.41        | 45.48        | 28.43        |              |              |              |              |              |              |               | D10 98.32  |
| Region D11                            | 35.58        | 47.89        | 44.72        |              |              |              |              |              |              |               | D11 127.99 |
| Region D12                            | 31.07        | 23.19        | 18.51        |              |              |              |              |              |              |               | D12 72.77  |
| Region E1                             | 24.00        | 37.89        | 23.68        |              |              |              |              |              |              |               | E1 85.57   |
| Region E2                             | 42.03        | 40.41        | 48.59        |              |              |              |              |              |              |               | E2 131.02  |
| Region E3                             | 46.07        | 45.09        | 40.03        |              |              |              |              |              |              |               | E3 133.99  |
| Region E4                             | 49.58        | 27.92        | 21.00        |              |              |              |              |              |              |               | E4 96.49   |
| Region E5                             | 34.97        | 31.81        | 47.85        |              |              |              |              |              |              |               | E5 114.64  |
| Region E6                             | 49.51        | 25.07        | 45.76        |              |              |              |              |              |              |               | E6 120.35  |
| Region E7                             | 40.07        | 22.05        | 42.11        |              |              |              |              |              |              |               | E7 104.22  |
| Region E8                             | 32.50        | 32.89        | 26.59        |              |              |              |              |              |              |               | E8 91.98   |
| Region E9                             | 19.99        | 45.10        | 31.94        |              |              |              |              |              |              |               | E9 97.03   |
| Region E10                            | 42.22        | 29.25        | 12.43        |              |              |              |              |              |              |               | E10 83.90  |
| Region E11                            | 46.00        | 40.52        | 47.82        |              |              |              |              |              |              |               | E11 134.54 |
| Region F1                             | 38.88        | 33.47        | 39.39        |              |              |              |              |              |              |               | F1 111.73  |
| Region F2                             | 32.90        | 47.85        | 32.82        |              |              |              |              |              |              |               | F2 113.46  |
| Region F3                             | 17.59        | 44.27        | 44.81        |              |              |              |              |              |              |               | F3 106.68  |
| Region F4                             | 35.75        | 45.06        | 48.12        |              |              |              |              |              |              |               | F4 128.93  |
| Region F5                             | 47.60        | 13.87        | 35.10        |              |              |              |              |              |              |               | F5 96.57   |
| Region F6                             | 60.44        | 36.19        | 32.24        |              |              |              |              |              |              |               | F6 118.88  |
| Region F7                             | 35.38        | 37.00        | 27.00        |              |              |              |              |              |              |               | F7 99.38   |
| Region F8                             | 33.36        | 36.45        | 31.88        |              |              |              |              |              |              |               | F8 99.38   |
| Region F9                             | 29.24        | 34.53        | 43.03        |              |              |              |              |              |              |               | F9 106.80  |
| Region F10                            | 35.96        | 37.30        | 41.98        |              |              |              |              |              |              |               | F10 115.24 |
| Region G1                             | 27.00        | 42.78        | 47.25        |              |              |              |              |              |              |               | G1 117.03  |
| Region G2                             | 39.00        | 45.69        | 36.10        |              |              |              |              |              |              |               | G2 120.79  |
| Region G3                             | 26.46        | 39.30        | 31.99        |              |              |              |              |              |              |               | G3 97.73   |
| Region G4                             | 39.29        | 27.00        | 35.22        |              |              |              |              |              |              |               | G4 101.50  |
| Total                                 | 2247.90      | 2375.14      | 2231.12      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |            |
| Maximum                               | 50.44        | 49.89        | 54.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |            |
| Minimum                               | 15.42        | 11.45        | 6.81         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |            |
| Average                               | 34.06        | 35.99        | 33.69        |              |              |              |              |              |              |               |            |
| Standard Deviation                    | 9.00         | 9.79         | 10.34        |              |              |              |              |              |              |               |            |
| Mode                                  | 24.00        | 24.00        | 24.00        |              |              |              |              |              |              |               |            |
| Median                                | 35.03        | 36.44        | 32.61        |              |              |              |              |              |              |               |            |
| Profitability Quotient                | 4.50         | 4.75         | 4.46         |              |              |              |              |              |              |               |            |
| 6054.15 Total All Simulations         |              |              |              |              |              |              |              |              |              |               |            |
| 54.00 Maximum All Simulations         |              |              |              |              |              |              |              |              |              |               |            |
| 9.00 Minimum All Simulations          |              |              |              |              |              |              |              |              |              |               |            |
| 34.62 Average All Simulations         |              |              |              |              |              |              |              |              |              |               |            |
| 0.0457 Profit Gauge                   |              |              |              |              |              |              |              |              |              |               |            |

Figure 34. Total mandatory profit per simulation report showing three simulations

|             |        |               |                    |   |           |
|-------------|--------|---------------|--------------------|---|-----------|
| simulation3 | 293.36 | 4/19/05 23:07 | 259 Diorite Street | 2 | Region F1 |
| simulation3 | 99.31  | 4/18/05 17:00 | 727 Diorite Street | 1 | Region F1 |
| simulation3 | 161.58 | 4/17/05 11:20 | 739 Diorite Street | 1 | Region F1 |
| simulation1 | 51.82  | 4/19/05 18:35 | 723 Genesis Road   | 1 | Region F2 |
| simulation1 | 235.06 | 4/18/05 10:37 | 86 Exodus Road     | 1 | Region F2 |
| simulation1 | 218.20 | 4/17/05 14:53 | 105 Exodus Road    | 1 | Region F2 |
| simulation1 | 250.51 | 4/18/05 14:47 | 249 Exodus Road    | 1 | Region F2 |
| simulation1 | 281.54 | 4/18/05 2:07  | 614 Exodus Road    | 1 | Region F2 |
| simulation1 | 151.42 | 4/18/05 7:18  | 809 Exodus Road    | 1 | Region F2 |
| simulation1 | 294.80 | 4/20/05 6:15  | 951 Exodus Road    | 2 | Region F2 |
| simulation1 | 131.26 | 4/19/05 8:21  | 328 Joshua Road    | 1 | Region F2 |
| simulation1 | 35.51  | 4/18/05 16:48 | 837 Joshua Road    | 1 | Region F2 |
| simulation2 | 178.46 | 4/18/05 16:33 | 166 Genesis Road   | 2 | Region F2 |
| simulation2 | 262.36 | 4/19/05 18:46 | 85 Exodus Road     | 3 | Region F2 |
| simulation2 | 295.07 | 4/18/05 3:18  | 134 Exodus Road    | 2 | Region F2 |
| simulation2 | 72.21  | 4/18/05 12:40 | 916 Exodus Road    | 2 | Region F2 |
| simulation2 | 222.04 | 4/19/05 21:47 | 257 Joshua Road    | 3 | Region F2 |
| simulation2 | 297.79 | 4/18/05 13:14 | 850 Joshua Road    | 2 | Region F2 |
| simulation2 | 247.23 | 4/19/05 4:48  | 875 Joshua Road    | 2 | Region F2 |
| simulation2 | 126.68 | 4/19/05 0:46  | 12 Ruth Street     | 2 | Region F2 |
| simulation2 | 247.95 | 4/20/05 5:34  | 671 Ruth Street    | 3 | Region F2 |
| simulation2 | 90.68  | 4/19/05 8:32  | 699 Ruth Street    | 2 | Region F2 |
| simulation2 | 96.69  | 4/17/05 14:55 | 757 Ruth Street    | 2 | Region F2 |
| simulation3 | 135.91 | 4/19/05 21:40 | 551 Genesis Road   | 3 | Region F2 |
| simulation3 | 225.05 | 4/18/05 5:46  | 695 Genesis Road   | 3 | Region F2 |
| simulation3 | 228.09 | 4/20/05 3:43  | 810 Genesis Road   | 3 | Region F2 |
| simulation3 | 103.34 | 4/18/05 23:29 | 188 Exodus Road    | 3 | Region F2 |
| simulation3 | 203.47 | 4/17/05 14:05 | 856 Ruth Street    | 3 | Region F2 |
| simulation1 | 136.92 | 4/19/05 8:56  | 566 Solomon Road   | 1 | Region F3 |
| simulation1 | 202.44 | 4/20/05 7:16  | 620 Isaiah Road    | 1 | Region F3 |
| simulation1 | 90.00  | 4/18/05 13:21 | 493 Hosea Road     | 1 | Region F3 |
| simulation2 | 119.74 | 4/18/05 2:52  | 276 Solomon Road   | 1 | Region F3 |
| simulation2 | 66.73  | 4/18/05 23:19 | 402 Solomon Road   | 1 | Region F3 |
| simulation2 | 68.90  | 4/19/05 0:02  | 467 Solomon Road   | 1 | Region F3 |
| simulation2 | 276.86 | 4/17/05 23:08 | 132 Isaiah Road    | 1 | Region F3 |
| simulation2 | 155.98 | 4/17/05 23:42 | 264 Isaiah Road    | 1 | Region F3 |
| simulation2 | 187.03 | 4/17/05 13:20 | 832 Isaiah Road    | 1 | Region F3 |
| simulation2 | 288.16 | 4/18/05 16:24 | 466 Hosea Road     | 1 | Region F3 |
| simulation1 | 294.47 | 4/18/05 2:33  | 877 Shang Road     | 1 | Region F4 |
| simulation1 | 207.91 | 4/19/05 21:11 | 943 Shang Road     | 1 | Region F4 |
| simulation1 | 287.38 | 4/20/05 6:24  | 137 Qin Street     | 2 | Region F4 |
| simulation1 | 50.90  | 4/19/05 5:29  | 170 Qin Street     | 1 | Region F4 |
| simulation1 | 118.85 | 4/17/05 16:10 | 337 Qin Street     | 1 | Region F4 |
| simulation1 | 244.82 | 4/18/05 18:15 | 447 Qin Street     | 4 | Region F4 |

Figure 35. Residence report showing orders from the second and third simulations

Profit Options

Profit Margin (in %)  Minimum Dollar Delivery

Mandatory Profit (overall regions)  leave this box blank if setting by concentric region

Or, Specify Mandatory Profit by Concentric Region

H  A  B  C

D  E  F  G

Delivery Charge (in dollars)  Submit Delivery Charge

Numbers in the table above are the amount of delivery charge being submitted.

Figure 36. Mandatory profit per concentric region on profit options form

| Settings Report                    |                 |                 |                            |                           |                  |            |
|------------------------------------|-----------------|-----------------|----------------------------|---------------------------|------------------|------------|
| Number of Simulations              |                 |                 | 1 Suppress Dispatch Alerts |                           | Yes              |            |
| Duration of Deliveries in Days     |                 |                 | 4 Allow Dispatch Alerts    |                           | No               |            |
| Simulation Times are Concatenated  |                 |                 |                            |                           | Yes              |            |
| Simulations Occur at the Same Time |                 |                 |                            |                           | No               |            |
| Profit Margin (in percent)         |                 |                 |                            |                           | 0.06             |            |
| Minimum Dollar Delivery            |                 |                 |                            |                           | 50               |            |
| Number of Orders per Simulation    |                 |                 |                            |                           | 2,000            |            |
| Region                             | Population x 10 | Delivery Charge | One-Way Drive Time         | Intra-Regional Drive Time | Mandatory Profit | Region     |
| Region H                           | 400             | 3.00            | 10                         | 5.00                      | 15               | Region H   |
| Region A1                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A1  |
| Region A2                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A2  |
| Region A3                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A3  |
| Region A4                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A4  |
| Region A5                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A5  |
| Region A6                          | 400             | 3.00            | 15                         | 5.00                      | 20               | Region A6  |
| Region B1                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B1  |
| Region B2                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B2  |
| Region B3                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B3  |
| Region B4                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B4  |
| Region B5                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B5  |
| Region B6                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B6  |
| Region B7                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B7  |
| Region B8                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B8  |
| Region B9                          | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B9  |
| Region B10                         | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B10 |
| Region B11                         | 400             | 3.00            | 20                         | 5.00                      | 20               | Region B11 |
| Region C1                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C1  |
| Region C2                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C2  |
| Region C3                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C3  |
| Region C4                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C4  |
| Region C5                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C5  |
| Region C6                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C6  |
| Region C7                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C7  |
| Region C8                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C8  |
| Region C9                          | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C9  |
| Region C10                         | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C10 |
| Region C11                         | 400             | 3.00            | 25                         | 5.00                      | 25               | Region C11 |
| Region D1                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D1  |
| Region D2                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D2  |
| Region D3                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D3  |
| Region D4                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D4  |
| Region D6                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D6  |
| Region D6                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D6  |
| Region D7                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D7  |
| Region D8                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D8  |
| Region D9                          | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D9  |
| Region D10                         | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D10 |
| Region D11                         | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D11 |
| Region D12                         | 400             | 3.00            | 30                         | 5.00                      | 30               | Region D12 |
| Region E1                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E1  |
| Region E2                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E2  |
| Region E3                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E3  |
| Region E4                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E4  |
| Region E5                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E5  |
| Region E6                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E6  |
| Region E7                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E7  |
| Region E8                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E8  |
| Region E9                          | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E9  |
| Region E10                         | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E10 |
| Region E11                         | 400             | 3.00            | 35                         | 5.00                      | 35               | Region E11 |
| Region F1                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F1  |
| Region F2                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F2  |
| Region F3                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F3  |
| Region F4                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F4  |
| Region F5                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F5  |
| Region F6                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F6  |
| Region F7                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F7  |
| Region F8                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F8  |
| Region F9                          | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F9  |
| Region F10                         | 400             | 3.00            | 40                         | 5.00                      | 40               | Region F10 |
| Region G1                          | 400             | 3.00            | 45                         | 5.00                      | 45               | Region G1  |
| Region G2                          | 400             | 3.00            | 45                         | 5.00                      | 45               | Region G2  |
| Region G3                          | 400             | 3.00            | 45                         | 5.00                      | 45               | Region G3  |
| Region G4                          | 400             | 3.00            | 45                         | 5.00                      | 45               | Region G4  |

Figure 37. Mandatory profit per concentric region on settings report

## DELIVERY CHARGE PER REGION

Select the delivery charge for each region.



Select the delivery charge for each region.

Profit Options
X

Profit Margin (in %) 0.06 Minimum Dollar Delivery 50

Mandatory Profit (overall regions) leave this box blank if setting by concentric region

Or, Specify Mandatory Profit by Concentric Region
 

|   |    |   |    |   |    |   |    |
|---|----|---|----|---|----|---|----|
| H | 15 | A | 20 | B | 25 | C | 30 |
| D | 35 | E | 40 | F | 45 | G | 50 |

Delivery Charge (in dollars) 3
Submit Delivery Charge

Instructions: In this block you are to select a price for each region.

Load Factor

Unit Conversion Factor

Figure 39. Delivery charge per region interface

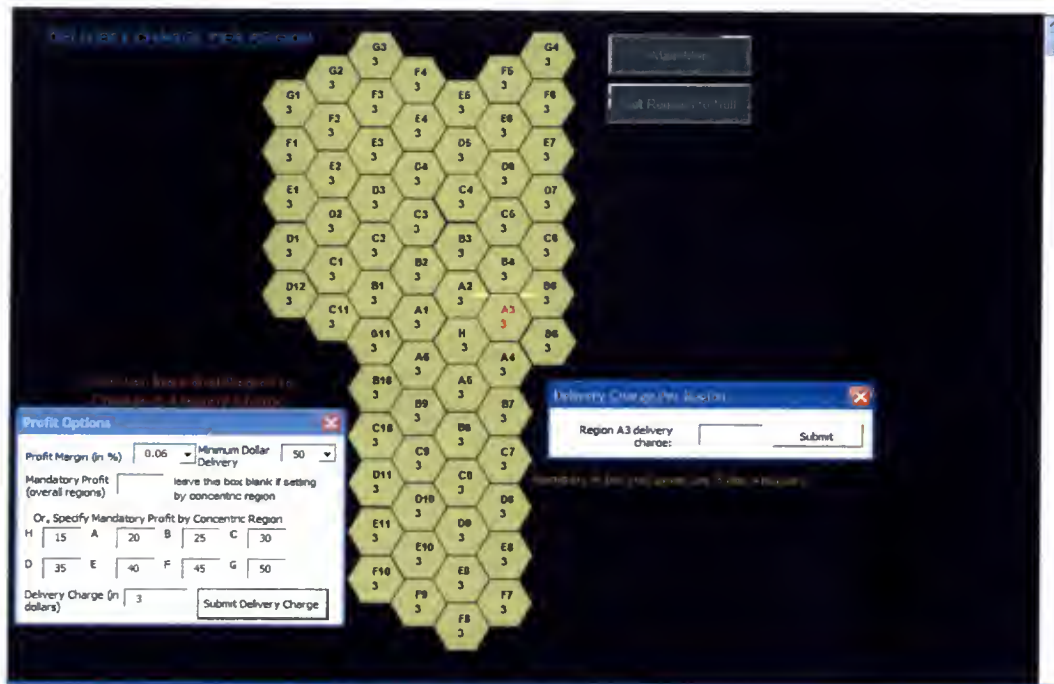


Figure 40. Delivery charge per region form

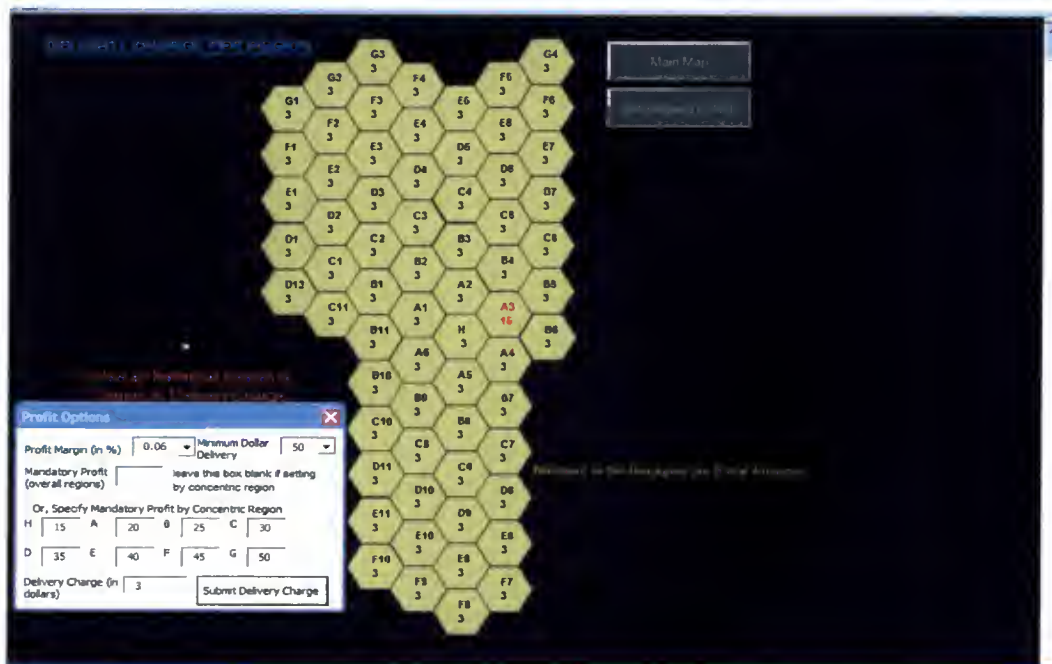


Figure 41. Region A3 showing the delivery charge



Figure 42. Profitability chart showing profit for region A3

| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |            |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone Total |
| Region H                              | 120.00       |              |              |              |              |              |              |              |              |               | H 120.00   |
| Region A1                             | 523.73       |              |              |              |              |              |              |              |              |               | A1 523.73  |
| Region A2                             | 559.28       |              |              |              |              |              |              |              |              |               | A2 559.28  |
| Region A3                             | 885.00       |              |              |              |              |              |              |              |              |               | A3 885.00  |
| Region A4                             | 238.15       |              |              |              |              |              |              |              |              |               | A4 238.15  |
| Region A5                             | 601.68       |              |              |              |              |              |              |              |              |               | A5 601.68  |
| Region A6                             | 165.00       |              |              |              |              |              |              |              |              |               | A6 165.00  |
| Region B1                             | 98.00        |              |              |              |              |              |              |              |              |               | B1 98.00   |
| Region B2                             | 307.16       |              |              |              |              |              |              |              |              |               | B2 307.16  |
| Region B3                             | 221.21       |              |              |              |              |              |              |              |              |               | B3 221.21  |
| Region B4                             | 534.06       |              |              |              |              |              |              |              |              |               | B4 534.06  |
| Region B5                             | 453.85       |              |              |              |              |              |              |              |              |               | B5 453.85  |
| Region B6                             | 139.48       |              |              |              |              |              |              |              |              |               | B6 139.48  |
| Region B7                             | 545.70       |              |              |              |              |              |              |              |              |               | B7 545.70  |
| Region B8                             | 635.58       |              |              |              |              |              |              |              |              |               | B8 635.58  |
| Region B9                             | 490.46       |              |              |              |              |              |              |              |              |               | B9 490.46  |
| Region B10                            | 120.00       |              |              |              |              |              |              |              |              |               | B10 120.00 |
| Region B11                            | 124.22       |              |              |              |              |              |              |              |              |               | B11 124.22 |
| Region C1                             | 419.73       |              |              |              |              |              |              |              |              |               | C1 419.73  |
| Region C2                             | 127.32       |              |              |              |              |              |              |              |              |               | C2 127.32  |
| Region C3                             | 404.79       |              |              |              |              |              |              |              |              |               | C3 404.79  |
| Region C4                             | 153.85       |              |              |              |              |              |              |              |              |               | C4 153.85  |
| Region C5                             | 123.00       |              |              |              |              |              |              |              |              |               | C5 123.00  |
| Region C6                             | 161.39       |              |              |              |              |              |              |              |              |               | C6 161.39  |
| Region C7                             | 339.25       |              |              |              |              |              |              |              |              |               | C7 339.25  |
| Region C8                             | 111.00       |              |              |              |              |              |              |              |              |               | C8 111.00  |
| Region C9                             | 509.32       |              |              |              |              |              |              |              |              |               | C9 509.32  |
| Region C10                            | 525.82       |              |              |              |              |              |              |              |              |               | C10 525.82 |
| Region C11                            | 600.34       |              |              |              |              |              |              |              |              |               | C11 600.34 |
| Region D1                             | 142.01       |              |              |              |              |              |              |              |              |               | D1 142.01  |
| Region D2                             | 506.90       |              |              |              |              |              |              |              |              |               | D2 506.90  |
| Region D3                             | 321.76       |              |              |              |              |              |              |              |              |               | D3 321.76  |
| Region D4                             | 284.22       |              |              |              |              |              |              |              |              |               | D4 284.22  |
| Region D5                             | 475.92       |              |              |              |              |              |              |              |              |               | D5 475.92  |
| Region D6                             | 344.31       |              |              |              |              |              |              |              |              |               | D6 344.31  |
| Region D7                             | 377.67       |              |              |              |              |              |              |              |              |               | D7 377.67  |
| Region D8                             | 563.58       |              |              |              |              |              |              |              |              |               | D8 563.58  |
| Region D9                             | 592.85       |              |              |              |              |              |              |              |              |               | D9 592.85  |
| Region D10                            | 468.49       |              |              |              |              |              |              |              |              |               | D10 468.49 |
| Region D11                            | 558.39       |              |              |              |              |              |              |              |              |               | D11 558.39 |
| Region D12                            | 253.24       |              |              |              |              |              |              |              |              |               | D12 253.24 |
| Region E1                             | 343.64       |              |              |              |              |              |              |              |              |               | E1 343.64  |
| Region E2                             | 405.33       |              |              |              |              |              |              |              |              |               | E2 405.33  |
| Region E3                             | 134.42       |              |              |              |              |              |              |              |              |               | E3 134.42  |
| Region E4                             | 633.36       |              |              |              |              |              |              |              |              |               | E4 633.36  |
| Region E5                             | 554.98       |              |              |              |              |              |              |              |              |               | E5 554.98  |
| Region E6                             | 400.67       |              |              |              |              |              |              |              |              |               | E6 400.67  |
| Region E7                             | 156.43       |              |              |              |              |              |              |              |              |               | E7 156.43  |
| Region E8                             | 470.56       |              |              |              |              |              |              |              |              |               | E8 470.56  |
| Region E9                             | 154.37       |              |              |              |              |              |              |              |              |               | E9 154.37  |

Figure 43. Total mandatory profit per simulation report showing profit for region A3

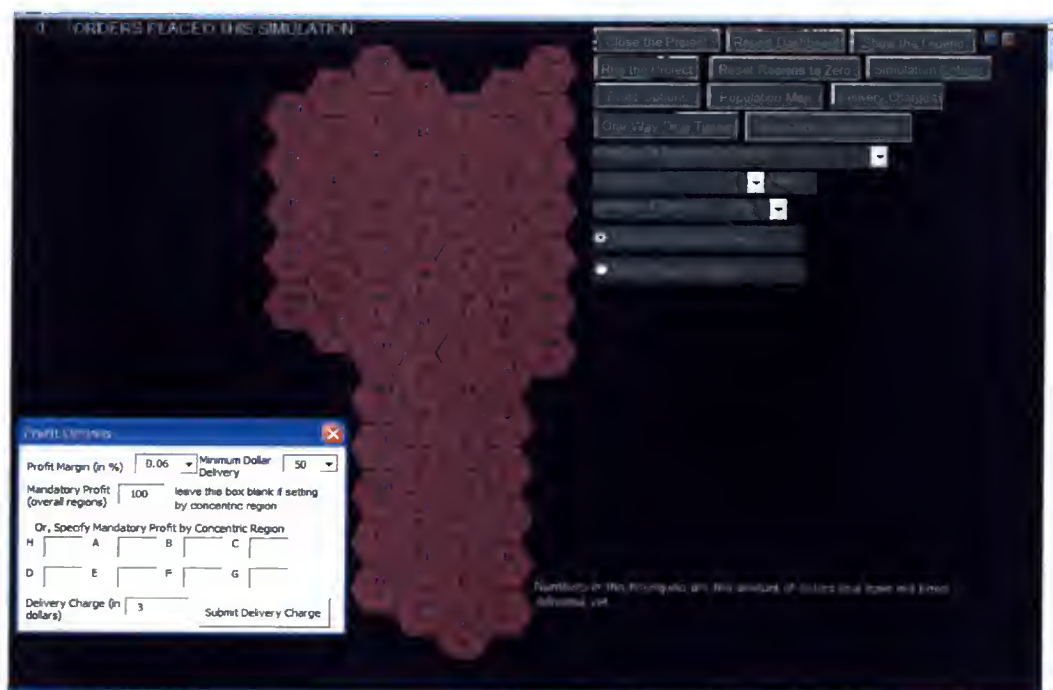


Figure 44. Settings used with Intra-Regional Drive Time function



Figure 45. Intra-regional drive time interface

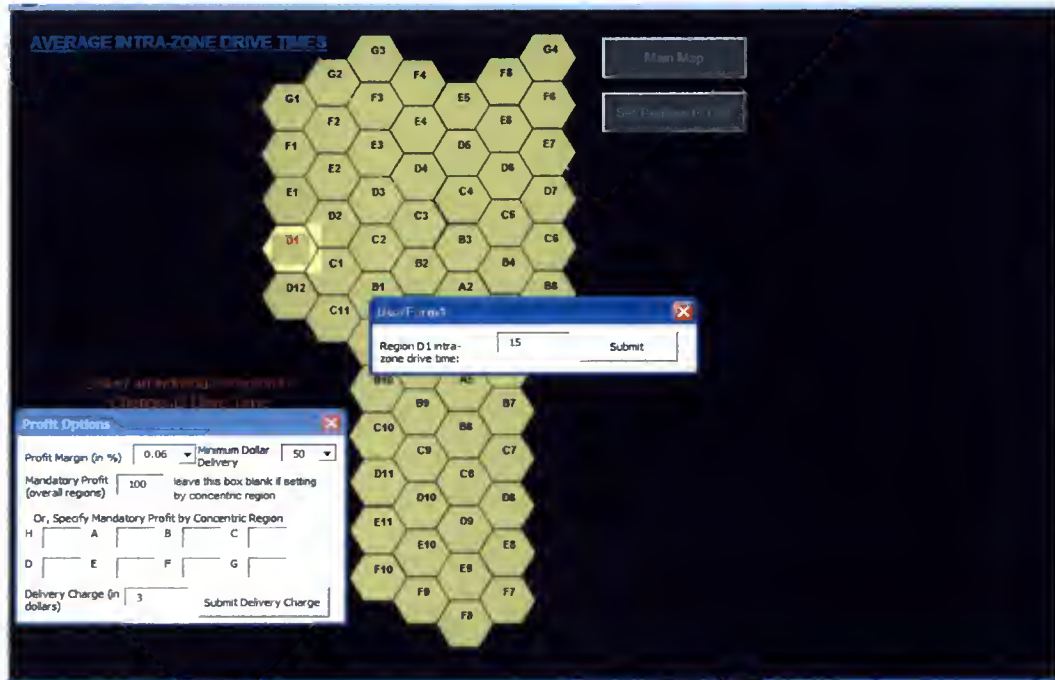


Figure 46. Intra-regional drive time pop-up form

| Region     | Population x 10 | Delivery Charge | One-Way Drive Time | Intra-Regional Drive Time | Mandatory Profit | Region     |
|------------|-----------------|-----------------|--------------------|---------------------------|------------------|------------|
| Region H   | 400             | 3.00            | 10                 | 5.00                      | 100              | Region H   |
| Region A1  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A1  |
| Region A2  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A2  |
| Region A3  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A3  |
| Region A4  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A4  |
| Region A5  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A5  |
| Region A6  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A6  |
| Region B1  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B1  |
| Region B2  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B2  |
| Region B3  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B3  |
| Region B4  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B4  |
| Region B5  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B5  |
| Region B6  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B6  |
| Region B7  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B7  |
| Region B8  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B8  |
| Region B9  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B9  |
| Region B10 | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B10 |
| Region B11 | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B11 |
| Region C1  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C1  |
| Region C2  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C2  |
| Region C3  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C3  |
| Region C4  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C4  |
| Region C5  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C5  |
| Region C6  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C6  |
| Region C7  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C7  |
| Region C8  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C8  |
| Region C9  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C9  |
| Region C10 | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C10 |
| Region C11 | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C11 |
| Region D1  | 400             | 3.00            | 30                 | 15.00                     | 100              | Region D1  |
| Region D2  | 400             | 3.00            | 30                 | 5.00                      | 100              | Region D2  |
| Region D3  | 400             | 3.00            | 30                 | 5.00                      | 100              | Region D3  |
| Region D4  | 400             | 3.00            | 30                 | 5.00                      | 100              | Region D4  |

Figure 47. Settings report showing 15 minute intra-regional drive time

| Simulation # | Truck and Region                 | Sent Time     | Return Time   | Round Trip Time | Gross Regional Profit | Gross Regional Profit - Mandatory Profit |
|--------------|----------------------------------|---------------|---------------|-----------------|-----------------------|------------------------------------------|
| Simulation 1 | Truck 1 dispatched to Region E8  | 4/22/05 2:59  | 4/22/05 5:00  | 2:01            | \$104.96              | \$4.96                                   |
| Simulation 1 | Truck 2 dispatched to Region B11 | 4/22/05 4:08  | 4/22/05 5:29  | 1:20            | \$112.17              | \$12.17                                  |
| Simulation 1 | Truck 1 dispatched to Region E7  | 4/22/05 5:29  | 4/22/05 7:18  | 1:49            | \$119.27              | \$19.27                                  |
| Simulation 1 | Truck 2 dispatched to Region G3  | 4/22/05 5:46  | 4/22/05 7:35  | 1:49            | \$110.95              | \$10.95                                  |
| Simulation 1 | Truck 3 dispatched to Region E6  | 4/22/05 6:49  | 4/22/05 8:45  | 1:55            | \$102.54              | \$2.54                                   |
| Simulation 1 | Truck 4 dispatched to Region E4  | 4/22/05 7:12  | 4/22/05 9:08  | 1:55            | \$101.59              | \$1.59                                   |
| Simulation 1 | Truck 1 dispatched to Region F4  | 4/22/05 9:25  | 4/22/05 11:32 | 2:06            | \$107.06              | \$7.06                                   |
| Simulation 1 | Truck 2 dispatched to Region C9  | 4/22/05 9:48  | 4/22/05 11:14 | 1:26            | \$104.76              | \$4.76                                   |
| Simulation 1 | Truck 3 dispatched to Region C6  | 4/22/05 11:09 | 4/22/05 12:35 | 1:26            | \$111.29              | \$11.29                                  |
| Simulation 1 | Truck 1 dispatched to Region C11 | 4/22/05 13:15 | 4/22/05 14:42 | 1:26            | \$105.21              | \$5.21                                   |
| Simulation 1 | Truck 1 dispatched to Region E8  | 4/22/05 15:16 | 4/22/05 17:46 | 2:29            | \$107.58              | \$7.58                                   |
| Simulation 1 | Truck 2 dispatched to Region B10 | 4/22/05 17:17 | 4/22/05 18:38 | 1:20            | \$100.98              | \$0.98                                   |
| Simulation 1 | Truck 1 dispatched to Region F1  | 4/22/05 20:51 | 4/22/05 22:57 | 2:06            | \$102.74              | \$2.74                                   |
| Simulation 1 | Truck 2 dispatched to Region D6  | 4/22/05 20:56 | 4/22/05 22:52 | 1:55            | \$111.95              | \$11.95                                  |
| Simulation 1 | Truck 3 dispatched to Region G4  | 4/22/05 21:25 | 4/22/05 23:32 | 2:06            | \$107.99              | \$7.99                                   |
| Simulation 1 | Truck 4 dispatched to Region D3  | 4/22/05 22:34 | 4/23/05 0:18  | 1:43            | \$112.04              | \$12.04                                  |
| Simulation 1 | Truck 1 dispatched to Region F2  | 4/23/05 0:01  | 4/23/05 2:13  | 2:12            | \$110.91              | \$10.91                                  |
| Simulation 1 | Truck 2 dispatched to Region F10 | 4/23/05 0:24  | 4/23/05 2:25  | 2:01            | \$113.78              | \$13.78                                  |
| Simulation 1 | Truck 3 dispatched to Region F7  | 4/23/05 1:56  | 4/23/05 3:51  | 1:55            | \$101.97              | \$1.97                                   |
| Simulation 1 | Truck 1 dispatched to Region D6  | 4/23/05 3:22  | 4/23/05 5:41  | 2:18            | \$109.90              | \$9.90                                   |
| Simulation 1 | Truck 2 dispatched to Region C4  | 4/23/05 4:31  | 4/23/05 5:58  | 1:26            | \$106.64              | \$6.64                                   |
| Simulation 1 | Truck 1 dispatched to Region A1  | 4/23/05 5:52  | 4/23/05 7:07  | 1:14            | \$106.20              | \$6.20                                   |
| Simulation 1 | Truck 2 dispatched to Region F4  | 4/23/05 6:32  | 4/23/05 9:02  | 2:29            | \$104.72              | \$4.72                                   |
| Simulation 1 | Truck 1 dispatched to Region D1  | 4/23/05 7:24  | 4/23/05 10:11 | 2:47            | \$101.49              | \$1.49                                   |
| Simulation 1 | Truck 3 dispatched to Region F8  | 4/23/05 7:53  | 4/23/05 10:00 | 2:06            | \$104.08              | \$4.08                                   |

Figure 48. Delivery report showing increased intra-regional drive times



Figure 49. Inter-regional drive time interface

| Settings Report                     |  |  |      |                          |  |     |
|-------------------------------------|--|--|------|--------------------------|--|-----|
| Number of Simulations:              |  |  | 1    | Suppress Dispatch Alerts |  | Yes |
| Duration of Deliveries in Days:     |  |  | 2    | Allow Dispatch Alerts    |  | No  |
| Simulation Times are Concatenated:  |  |  | Yes  |                          |  |     |
| Simulations Occur at the Same Time: |  |  | No   |                          |  |     |
| Profit Margin (in percent):         |  |  | 0.06 |                          |  |     |
| Minimum Dollar Delivery:            |  |  | 50   |                          |  |     |
| Number of Orders per Simulation:    |  |  | 500  |                          |  |     |

| Region     | Population x 10 | Delivery Charge | One-Way Drive Time | Intra-Regional Drive Time | Mandatory Profit | Region     |
|------------|-----------------|-----------------|--------------------|---------------------------|------------------|------------|
| Region H   | 400             | 3.00            | 10                 | 5.00                      | 100              | Region H   |
| Region A1  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A1  |
| Region A2  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A2  |
| Region A3  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A3  |
| Region A4  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A4  |
| Region A5  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A5  |
| Region A6  | 400             | 3.00            | 15                 | 5.00                      | 100              | Region A6  |
| Region B1  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B1  |
| Region B2  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B2  |
| Region B3  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B3  |
| Region B4  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B4  |
| Region B5  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B5  |
| Region B6  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B6  |
| Region B7  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B7  |
| Region B8  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B8  |
| Region B9  | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B9  |
| Region B10 | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B10 |
| Region B11 | 400             | 3.00            | 20                 | 5.00                      | 100              | Region B11 |
| Region C1  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C1  |
| Region C2  | 400             | 3.00            | 90                 | 5.00                      | 100              | Region C2  |
| Region C3  | 400             | 3.00            | 90                 | 5.00                      | 100              | Region C3  |
| Region C4  | 400             | 3.00            | 90                 | 5.00                      | 100              | Region C4  |
| Region C5  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C5  |
| Region C6  | 400             | 3.00            | 25                 | 5.00                      | 100              | Region C6  |

Figure 50. Settings report showing increased inter-regional drive time

| Delivery Report |                                  |               |               |                 |                       |                  |
|-----------------|----------------------------------|---------------|---------------|-----------------|-----------------------|------------------|
| Simulation #    | Truck and Region                 | Sent Time     | Return Time   | Round Trip Time | Gross Regional Profit | Mandatory Profit |
| Simulation 1    | Truck 1 dispatched to Region D7  | 4/22/05 2:44  | 4/22/05 4:22  | 1:37            | \$100.65              | \$0.65           |
| Simulation 1    | Truck 1 dispatched to Region F10 | 4/22/05 7:33  | 4/22/05 9:39  | 2:06            | \$116.92              | \$16.92          |
| Simulation 1    | Truck 2 dispatched to Region F8  | 4/22/05 9:10  | 4/22/05 11:06 | 1:55            | \$103.05              | \$3.05           |
| Simulation 1    | Truck 1 dispatched to Region D5  | 4/22/05 14:50 | 4/22/05 16:28 | 1:37            | \$103.74              | \$3.74           |
| Simulation 1    | Truck 1 dispatched to Region B4  | 4/22/05 18:00 | 4/22/05 19:21 | 1:20            | \$110.72              | \$10.72          |
| Simulation 1    | Truck 2 dispatched to Region C2  | 4/22/05 18:41 | 4/22/05 22:26 | 3:44            | \$112.11              | \$12.11          |
| Simulation 1    | Truck 1 dispatched to Region E6  | 4/22/05 21:57 | 4/22/05 23:52 | 1:55            | \$108.01              | \$8.01           |
| Simulation 1    | Truck 2 dispatched to Region E7  | 4/22/05 23:12 | 4/23/05 1:18  | 2:06            | \$105.43              | \$5.43           |
| Simulation 1    | Truck 3 dispatched to Region B10 | 4/22/05 23:40 | 4/23/05 1:13  | 1:32            | \$104.91              | \$4.91           |
| Simulation 1    | Truck 4 dispatched to Region A2  | 4/22/05 23:46 | 4/23/05 1:01  | 1:14            | \$115.39              | \$15.39          |
| Simulation 1    | Truck 1 dispatched to Region A4  | 4/22/05 23:52 | 4/23/05 1:07  | 1:14            | \$111.02              | \$11.02          |
| Simulation 1    | Truck 5 dispatched to Region C3  | 4/23/05 0:03  | 4/23/05 3:48  | 3:44            | \$110.01              | \$10.01          |
| Simulation 1    | Truck 4 dispatched to Region F9  | 4/23/05 1:01  | 4/23/05 3:08  | 2:06            | \$107.37              | \$7.37           |
| Simulation 1    | Truck 1 dispatched to Region C1  | 4/23/05 1:07  | 4/23/05 2:33  | 1:26            | \$108.74              | \$8.74           |
| Simulation 1    | Truck 2 dispatched to Region B2  | 4/23/05 2:04  | 4/23/05 3:31  | 1:26            | \$101.95              | \$1.95           |
| Simulation 1    | Truck 1 dispatched to Region C11 | 4/23/05 3:08  | 4/23/05 4:57  | 1:49            | \$114.20              | \$14.20          |
| Simulation 1    | Truck 2 dispatched to Region B9  | 4/23/05 4:23  | 4/23/05 5:43  | 1:20            | \$101.71              | \$1.71           |
| Simulation 1    | Truck 3 dispatched to Region E1  | 4/23/05 4:40  | 4/23/05 6:35  | 1:55            | \$110.41              | \$10.41          |
| Simulation 1    | Truck 1 dispatched to Region C5  | 4/23/05 6:01  | 4/23/05 7:21  | 1:20            | \$101.88              | \$1.88           |
| Simulation 1    | Truck 2 dispatched to Region D6  | 4/23/05 6:12  | 4/23/05 8:02  | 1:49            | \$103.78              | \$3.78           |
| Simulation 1    | Truck 4 dispatched to Region B8  | 4/23/05 6:30  | 4/23/05 7:56  | 1:26            | \$114.00              | \$14.00          |
| Simulation 1    | Truck 3 dispatched to Region D2  | 4/23/05 7:04  | 4/23/05 8:42  | 1:37            | \$110.63              | \$10.63          |
| Simulation 1    | Truck 1 dispatched to Region C9  | 4/23/05 7:44  | 4/23/05 9:11  | 1:26            | \$116.80              | \$16.80          |
| Simulation 1    | Truck 2 dispatched to Region A6  | 4/23/05 8:07  | 4/23/05 9:22  | 1:14            | \$101.07              | \$1.07           |
| Simulation 1    | Truck 4 dispatched to Region A3  | 4/23/05 8:19  | 4/23/05 9:40  | 1:20            | \$103.01              | \$3.01           |

Figure 51. Delivery report showing increased inter-regional drive times

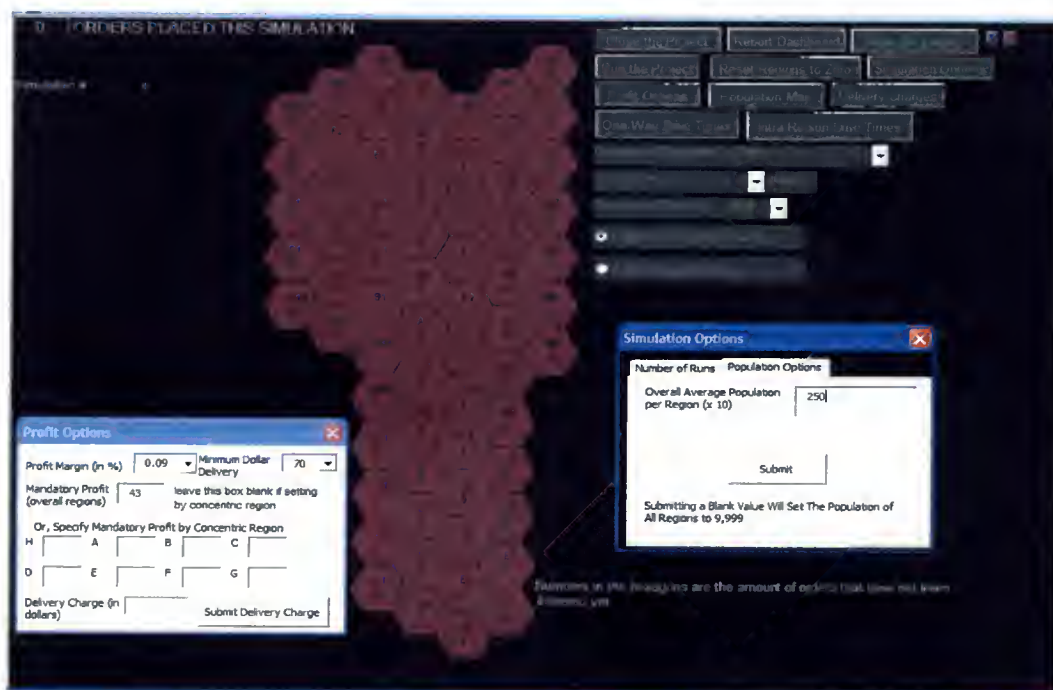


Figure 52. Overall average population per region

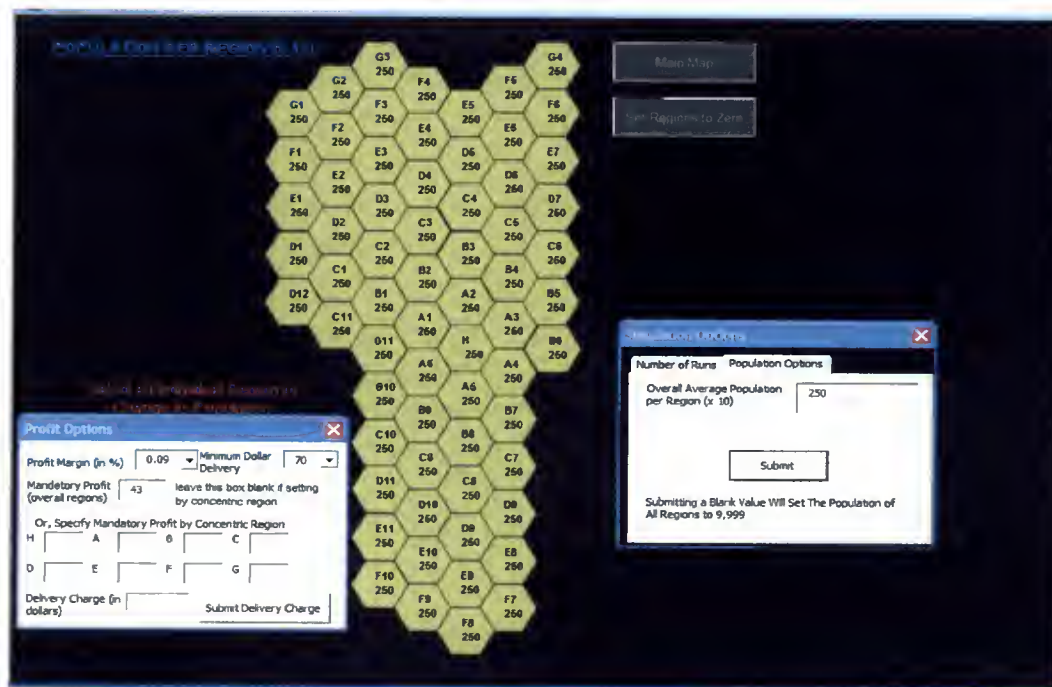


Figure 53. Population per region interface

### 2000 VORDERS PLACED THIS SIMULATION

The # of Vorders Placed This Region At: 402/1000 5:05  
 The Last Vorder Placed This Region At: 4/2/760 8:15

Simulation # 11

Track 1: Dispatched to Region F-1  
 Track 2: Dispatched to Region E-1  
 Track 3: Dispatched to Region F-1  
 Track 4: at home  
 Track 5: Dispatched to Region E-1  
 Track 6: Dispatched to Region F-1  
 Track 7: Dispatched to Region E-1  
 Track 8: Dispatched to Region E-1  
 Track 9: at home  
 Track 10: at home  
 Track 11: at home  
 Track 12: at home  
 Track 13: at home  
 Track 14: at home  
 Track 15: at home  
 Vorders left in region B: none

Close the Year

Print the Profit

Print Cumulative

One Way Drive Times

Print Dispatch

Print Regions in Zero

Print Region Map

Area Region Drive Times

Print Cumulative

Print Regions in Zero

Print Region Map

Area Region Drive Times

### Profit Options

Profit Margin (in %)  Minimum Dollar Delivery

Mandatory Profit (overall regions)  leave this box blank if setting by concentric region

Or, Specify Mandatory Profit by Concentric Region

H  A  B  C

D  E  F  G

Delivery Charge (in dollars)  Submit Delivery Charge

### Concentric Region Profit Options

|       |       |
|-------|-------|
| 0     | 21-30 |
| 1-5   | 31-35 |
| 6-10  | 36-40 |
| 11-15 | 41-45 |

Figure 55. Regions showing higher and zero populations

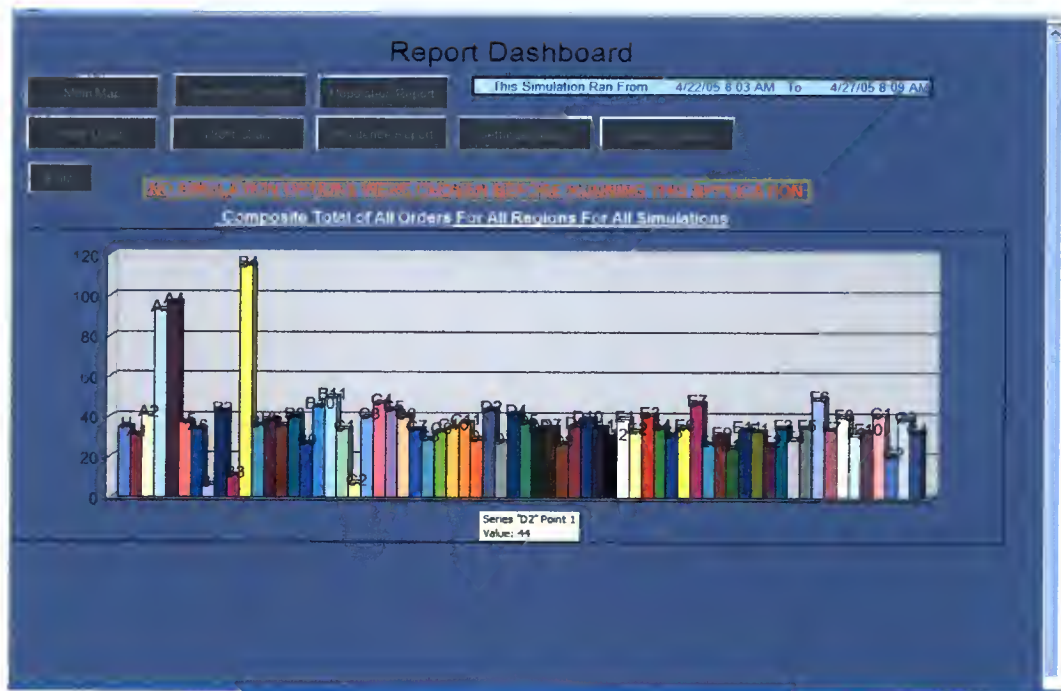


Figure 56. Report dashboard showing various populations

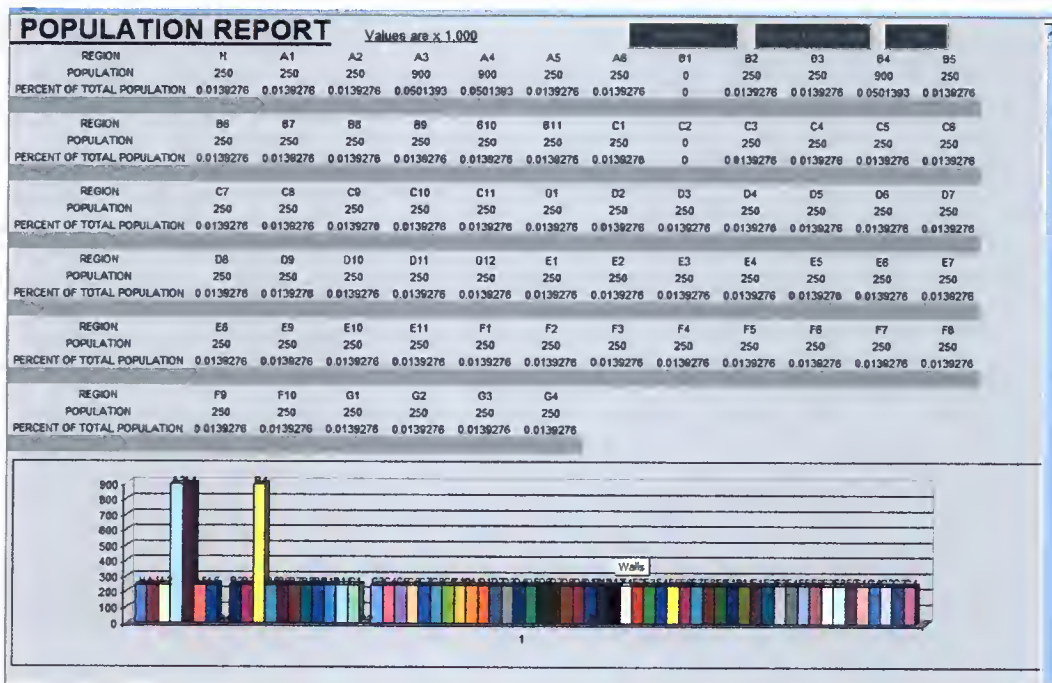


Figure 57. Population report showing various populations

### THREE SIMULATION SEQUENCES THAT RESULTED IN EXCEPTIONAL, AVERAGE, AND LOW PROFITABILITY

This chapter contains three scenarios that compare the overall Mandatory Profit of three runs. The first scenario will show a high overall Mandatory Profit. The second scenario will show a low overall Mandatory Profit. The third scenario will show a medium overall Mandatory Profit. What is demonstrated here is that by altering the various variables inherent in the application, the grocer can create scenarios where profit will be inferior, average, or superior. This valuable capability lets the user who may be uncertain about cyclical customer demand see the outcome of attempting deliveries under various circumstances. This is but another trait that is unique to this logistical application.

#### **Exceptional Profit**

Figure 58 shows the Main Map with the criteria set to run a simulation that will generate a high profit. Notice that the population is set to 9,999 households per region. Figure 59 shows the Profit Report for this simulation. At the very bottom of the Profit Report is the Profit Gauge. The Profit Gauge is a relative measure that can be used to compare the Profit earned between *SERIES* of simulations. It does not, for example, compare the profit between simulation 1 and simulation 2 of the same simulation series. It does, however, compare the profit between series of simulations. This is because each series of simulations (the simulations that occur in sequence after you hit the Run the Project button, and until the last simulation finishes) has different Profit Option setting.

The Profit Gauge is a simple, but effective number between 0 and 1 which is the total profit earned during a series of simulations divided by the number of grocery orders for that simulation sequence divided by 100. The higher the number, the greater the relative Mandatory Profit earned. The Profit Gauge for this simulation sequence is 0.2018 (very bottom of Figure 59).

### **Low Profit**

Figure 60 shows the Main Map with the criteria set to run a simulation that will generate a low profit. What is not shown is that the population is set to 500 households per region – a much lower density than the prior simulation that had 9,999 households per region. Also compare the lower profit margin, and delivery cost with those of the prior simulation.

The very bottom of Figure 61 shows the Profit Gauge of 0.0138 for this simulation. Compare this with the Profit Gauge of 0.2018 for the prior simulation.

### **Medium Profit**

Figure 62 shows the Main Map with the criteria set to run a simulation that will generate a profit intermediate between the high and low profit levels that were generated in the two prior simulation sequences. The population is set to 4,000 households per region – which is of course between 9,999 and 500 households that was set in the prior two simulations. Also compare the intermediate profit margins, and delivery costs with those of the two prior simulations.

The very bottom of Figure 63 shows the Profit Gauge of 0.0808 for this simulation. Compare this with the Profit Gauge of 0.2018 for the high profit simulation sequence and the Profit Gauge of 0.0138 for the low profit simulation sequence.

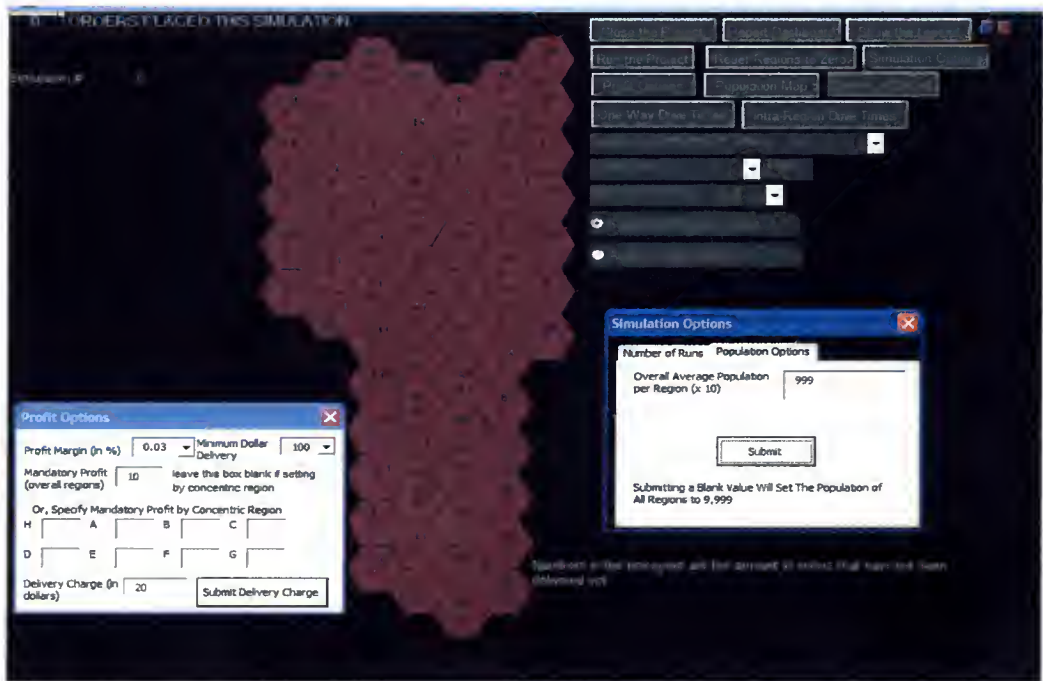


Figure 58. Profit and simulation options for high-profit scenario

| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |      |        |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------|--------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone | Total  |
| Region H                              | 120.00       | 220.00       |              |              |              |              |              |              |              |               | H    | 340.00 |
| Region A1                             | 140.00       | 200.00       |              |              |              |              |              |              |              |               | A1   | 340.00 |
| Region A2                             | 240.00       | 144.84       |              |              |              |              |              |              |              |               | A2   | 384.84 |
| Region A3                             | 160.00       | 140.00       |              |              |              |              |              |              |              |               | A3   | 300.00 |
| Region A4                             | 220.00       | 100.00       |              |              |              |              |              |              |              |               | A4   | 320.00 |
| Region A5                             | 160.00       | 160.00       |              |              |              |              |              |              |              |               | A5   | 320.00 |
| Region A6                             | 200.00       | 125.09       |              |              |              |              |              |              |              |               | A6   | 325.09 |
| Region B1                             | 200.00       | 100.00       |              |              |              |              |              |              |              |               | B1   | 300.00 |
| Region B2                             | 100.00       | 160.00       |              |              |              |              |              |              |              |               | B2   | 260.00 |
| Region B3                             | 120.00       | 180.00       |              |              |              |              |              |              |              |               | B3   | 300.00 |
| Region B4                             | 100.00       | 180.00       |              |              |              |              |              |              |              |               | B4   | 280.00 |
| Region B5                             | 120.00       | 280.00       |              |              |              |              |              |              |              |               | B5   | 400.00 |
| Region B6                             | 160.00       | 168.47       |              |              |              |              |              |              |              |               | B6   | 328.47 |
| Region B7                             | 160.00       | 183.24       |              |              |              |              |              |              |              |               | B7   | 343.24 |
| Region B8                             | 140.00       | 60.00        |              |              |              |              |              |              |              |               | B8   | 200.00 |
| Region B9                             | 20.00        | 120.00       |              |              |              |              |              |              |              |               | B9   | 140.00 |
| Region B10                            | 200.00       | 140.00       |              |              |              |              |              |              |              |               | B10  | 340.00 |
| Region B11                            | 167.52       | 224.89       |              |              |              |              |              |              |              |               | B11  | 392.41 |
| Region C1                             | 200.00       | 120.00       |              |              |              |              |              |              |              |               | C1   | 320.00 |
| Region C2                             | 80.00        | 180.00       |              |              |              |              |              |              |              |               | C2   | 240.00 |
| Region C3                             | 220.00       | 120.00       |              |              |              |              |              |              |              |               | C3   | 340.00 |
| Region C4                             | 140.00       | 185.10       |              |              |              |              |              |              |              |               | C4   | 365.10 |
| Region C5                             | 80.00        | 100.00       |              |              |              |              |              |              |              |               | C5   | 180.00 |
| Region C6                             | 40.00        | 128.13       |              |              |              |              |              |              |              |               | C6   | 168.13 |
| Region C7                             | 120.00       | 240.00       |              |              |              |              |              |              |              |               | C7   | 360.00 |
| Region C8                             | 180.00       | 260.00       |              |              |              |              |              |              |              |               | C8   | 420.00 |
| Region C9                             | 140.00       | 80.00        |              |              |              |              |              |              |              |               | C9   | 200.00 |
| Region C10                            | 140.00       | 148.85       |              |              |              |              |              |              |              |               | C10  | 288.85 |
| Region C11                            | 100.00       | 240.00       |              |              |              |              |              |              |              |               | C11  | 340.00 |
| Region D1                             | 180.00       | 147.84       |              |              |              |              |              |              |              |               | D1   | 327.84 |
| Region D2                             | 100.00       | 160.00       |              |              |              |              |              |              |              |               | D2   | 260.00 |
| Region D3                             | 80.00        | 80.00        |              |              |              |              |              |              |              |               | D3   | 140.00 |
| Region D4                             | 126.00       | 160.00       |              |              |              |              |              |              |              |               | D4   | 286.00 |
| Region D5                             | 40.00        | 260.00       |              |              |              |              |              |              |              |               | D5   | 300.00 |
| Region D6                             | 200.00       | 160.00       |              |              |              |              |              |              |              |               | D6   | 360.00 |
| Region D7                             | 140.00       | 100.00       |              |              |              |              |              |              |              |               | D7   | 240.00 |
| Region D8                             | 220.00       | 100.00       |              |              |              |              |              |              |              |               | D8   | 320.00 |
| Region D9                             | 180.00       | 188.45       |              |              |              |              |              |              |              |               | D9   | 348.45 |
| Region D10                            | 220.00       | 203.31       |              |              |              |              |              |              |              |               | D10  | 423.31 |
| Region D11                            | 268.89       | 126.67       |              |              |              |              |              |              |              |               | D11  | 395.47 |
| Region D12                            | 167.53       | 160.00       |              |              |              |              |              |              |              |               | D12  | 347.53 |
| Region E1                             | 160.00       | 300.00       |              |              |              |              |              |              |              |               | E1   | 460.00 |
| Region E2                             | 268.84       | 80.00        |              |              |              |              |              |              |              |               | E2   | 348.84 |
| Region E3                             | 180.00       | 80.00        |              |              |              |              |              |              |              |               | E3   | 260.00 |
| Region E4                             | 200.00       | 285.30       |              |              |              |              |              |              |              |               | E4   | 485.30 |
| Region E5                             | 180.00       | 140.00       |              |              |              |              |              |              |              |               | E5   | 320.00 |
| Region E6                             | 120.00       | 40.00        |              |              |              |              |              |              |              |               | E6   | 160.00 |
| Region E7                             | 120.00       | 147.53       |              |              |              |              |              |              |              |               | E7   | 267.53 |
| Region E8                             | 80.00        | 180.00       |              |              |              |              |              |              |              |               | E8   | 260.00 |
| Region E9                             | 180.00       | 180.00       |              |              |              |              |              |              |              |               | E9   | 360.00 |
| Region E10                            | 200.00       | 100.00       |              |              |              |              |              |              |              |               | E10  | 300.00 |
| Region E11                            | 120.00       | 60.00        |              |              |              |              |              |              |              |               | E11  | 180.00 |
| Region F1                             | 267.67       | 106.88       |              |              |              |              |              |              |              |               | F1   | 374.55 |
| Region F2                             | 140.00       | 160.00       |              |              |              |              |              |              |              |               | F2   | 300.00 |
| Region F3                             | 140.00       | 120.00       |              |              |              |              |              |              |              |               | F3   | 260.00 |
| Region F4                             | 172.17       | 60.00        |              |              |              |              |              |              |              |               | F4   | 232.17 |
| Region F5                             | 80.00        | 180.00       |              |              |              |              |              |              |              |               | F5   | 260.00 |
| Region F6                             | 180.00       | 220.00       |              |              |              |              |              |              |              |               | F6   | 400.00 |
| Region F7                             | 200.00       | 146.65       |              |              |              |              |              |              |              |               | F7   | 346.65 |
| Region F8                             | 120.00       | 140.00       |              |              |              |              |              |              |              |               | F8   | 260.00 |
| Region F9                             | 160.00       | 148.43       |              |              |              |              |              |              |              |               | F9   | 308.43 |
| Region F10                            | 128.98       | 180.00       |              |              |              |              |              |              |              |               | F10  | 308.98 |
| Region G1                             | 180.00       | 120.00       |              |              |              |              |              |              |              |               | G1   | 300.00 |
| Region G2                             | 160.00       | 120.00       |              |              |              |              |              |              |              |               | G2   | 280.00 |
| Region G3                             | 140.00       | 140.00       |              |              |              |              |              |              |              |               | G3   | 280.00 |
| Region G4                             | 140.00       | 203.82       |              |              |              |              |              |              |              |               | G4   | 343.82 |
| Total                                 | 10067.52     | 10113.45     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Maximum                               | 268.84       | 300.00       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Minimum                               | 20.00        | 40.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Average                               | 152.54       | 153.23       |              |              |              |              |              |              |              |               |      |        |
| Standard Deviation                    | 52.85        | 57.36        |              |              |              |              |              |              |              |               |      |        |
| Mode                                  | 140.00       | 180.00       |              |              |              |              |              |              |              |               |      |        |
| Median                                | 160.00       | 143.13       |              |              |              |              |              |              |              |               |      |        |
| Profitability Quotient                | 20.14        | 20.23        |              |              |              |              |              |              |              |               |      |        |
| 20180.98 Total All Simulations        |              |              |              |              |              |              |              |              |              |               |      |        |
| 300.00 Maximum All Simulations        |              |              |              |              |              |              |              |              |              |               |      |        |
| 0.00 Minimum All Simulations          |              |              |              |              |              |              |              |              |              |               |      |        |
| 152.89 Average All Simulations        |              |              |              |              |              |              |              |              |              |               |      |        |
| 0.2018 Profit Gauge                   |              |              |              |              |              |              |              |              |              |               |      |        |

Figure 59. Profitability quotient and profit gauge for high-profit scenario

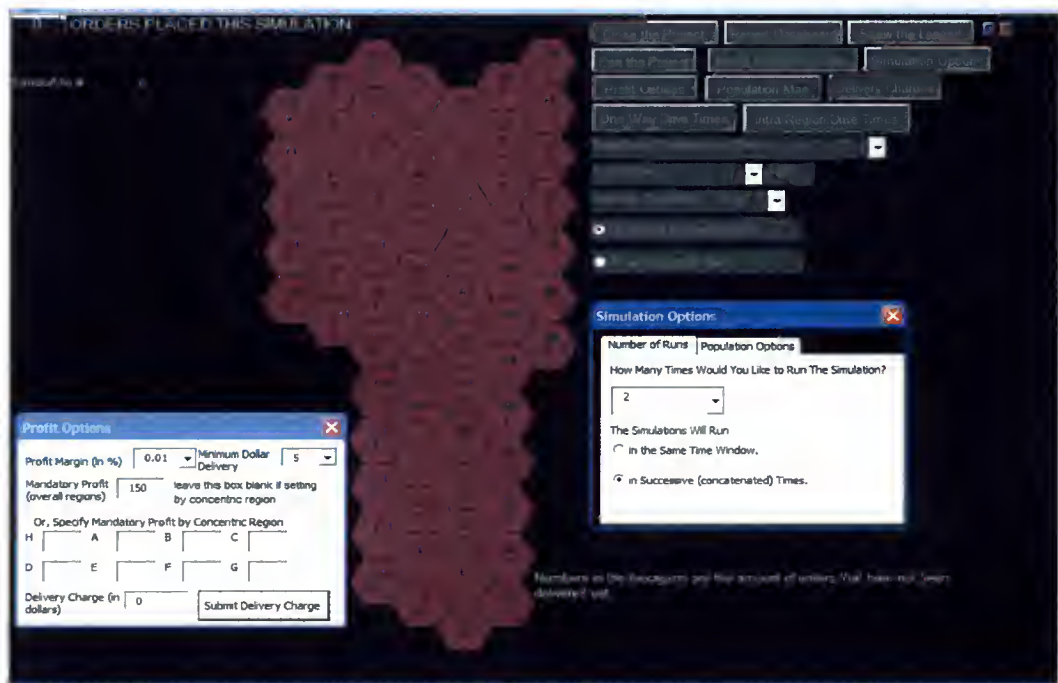


Figure 60. Profit and simulation options for low-profit scenario

| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |      |       |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------|-------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone | Total |
| Region H                              | 1.74         | 12.06        |              |              |              |              |              |              |              |               | H    | 14.80 |
| Region A1                             | 13.90        | 16.58        |              |              |              |              |              |              |              |               | A1   | 30.46 |
| Region A2                             | 5.81         | 10.17        |              |              |              |              |              |              |              |               | A2   | 15.98 |
| Region A3                             | 18.58        | 4.38         |              |              |              |              |              |              |              |               | A3   | 22.96 |
| Region A4                             | 13.52        | 7.35         |              |              |              |              |              |              |              |               | A4   | 20.87 |
| Region A5                             | 5.92         | 13.21        |              |              |              |              |              |              |              |               | A5   | 19.13 |
| Region A6                             | 13.34        | 12.69        |              |              |              |              |              |              |              |               | A6   | 26.03 |
| Region B1                             | 6.85         | 9.70         |              |              |              |              |              |              |              |               | B1   | 16.55 |
| Region B2                             | 19.02        | 6.20         |              |              |              |              |              |              |              |               | B2   | 27.22 |
| Region B3                             | 4.32         | 13.32        |              |              |              |              |              |              |              |               | B3   | 16.64 |
| Region B4                             | 16.21        | 5.66         |              |              |              |              |              |              |              |               | B4   | 21.87 |
| Region B6                             | 6.12         | 2.13         |              |              |              |              |              |              |              |               | B6   | 6.25  |
| Region B6                             | 6.20         | 7.84         |              |              |              |              |              |              |              |               | B6   | 15.23 |
| Region B7                             | 6.21         | 11.75        |              |              |              |              |              |              |              |               | B7   | 17.96 |
| Region B6                             | 9.17         | 18.55        |              |              |              |              |              |              |              |               | B6   | 25.72 |
| Region B8                             | 10.00        | 11.61        |              |              |              |              |              |              |              |               | B9   | 21.61 |
| Region D10                            | 6.61         | 12.65        |              |              |              |              |              |              |              |               | B10  | 21.46 |
| Region B11                            | 6.95         | 13.64        |              |              |              |              |              |              |              |               | B11  | 18.59 |
| Region C1                             | 11.16        | 16.36        |              |              |              |              |              |              |              |               | C1   | 29.54 |
| Region C2                             | 1.52         | 11.86        |              |              |              |              |              |              |              |               | C2   | 13.18 |
| Region C3                             | 22.75        | 6.94         |              |              |              |              |              |              |              |               | C3   | 26.70 |
| Region C4                             | 4.76         | 15.63        |              |              |              |              |              |              |              |               | C4   | 26.38 |
| Region C6                             | 5.38         | 7.06         |              |              |              |              |              |              |              |               | C5   | 12.44 |
| Region C9                             | 18.52        | 11.23        |              |              |              |              |              |              |              |               | C6   | 26.74 |
| Region C7                             | 14.71        | 3.86         |              |              |              |              |              |              |              |               | C7   | 16.57 |
| Region C8                             | 12.23        | 2.11         |              |              |              |              |              |              |              |               | C8   | 14.33 |
| Region C9                             | 11.99        | 6.85         |              |              |              |              |              |              |              |               | C9   | 16.64 |
| Region C10                            | 6.90         | 13.70        |              |              |              |              |              |              |              |               | C10  | 22.80 |
| Region C11                            | 13.21        | 4.66         |              |              |              |              |              |              |              |               | C11  | 16.95 |
| Region D1                             | 4.63         | 6.15         |              |              |              |              |              |              |              |               | D1   | 10.76 |
| Region D2                             | 15.67        | 5.20         |              |              |              |              |              |              |              |               | D2   | 20.67 |
| Region D3                             | 16.83        | 6.61         |              |              |              |              |              |              |              |               | D3   | 27.43 |
| Region D4                             | 9.46         | 4.80         |              |              |              |              |              |              |              |               | D4   | 14.26 |
| Region D5                             | 9.65         | 13.42        |              |              |              |              |              |              |              |               | D5   | 20.07 |
| Region D6                             | 16.54        | 11.59        |              |              |              |              |              |              |              |               | D6   | 30.13 |
| Region D7                             | 13.09        | 10.76        |              |              |              |              |              |              |              |               | D7   | 23.85 |
| Region D8                             | 10.98        | 11.00        |              |              |              |              |              |              |              |               | D8   | 21.98 |
| Region D8                             | 11.82        | 16.70        |              |              |              |              |              |              |              |               | D8   | 27.63 |
| Region D16                            | 7.03         | 7.01         |              |              |              |              |              |              |              |               | D10  | 14.04 |
| Region D11                            | 14.20        | 11.45        |              |              |              |              |              |              |              |               | D11  | 25.65 |
| Region D12                            | 14.66        | 11.06        |              |              |              |              |              |              |              |               | D12  | 26.52 |
| Region E1                             | 11.63        | 6.85         |              |              |              |              |              |              |              |               | E1   | 21.66 |
| Region E2                             | 16.12        | 11.10        |              |              |              |              |              |              |              |               | E2   | 29.22 |
| Region E3                             | 6.80         | 11.39        |              |              |              |              |              |              |              |               | E3   | 20.99 |
| Region E4                             | 4.64         | 3.62         |              |              |              |              |              |              |              |               | E4   | 8.26  |
| Region E6                             | 14.06        | 13.51        |              |              |              |              |              |              |              |               | E5   | 27.54 |
| Region E8                             | 16.39        | 12.51        |              |              |              |              |              |              |              |               | E6   | 30.90 |
| Region E7                             | 6.73         | 12.17        |              |              |              |              |              |              |              |               | E7   | 17.90 |
| Region E8                             | 13.30        | 10.59        |              |              |              |              |              |              |              |               | E8   | 23.90 |
| Region E9                             | 8.93         | 1.54         |              |              |              |              |              |              |              |               | E9   | 10.47 |
| Region E10                            | 12.46        | 6.98         |              |              |              |              |              |              |              |               | E10  | 19.44 |
| Region E11                            | 8.78         | 11.25        |              |              |              |              |              |              |              |               | E11  | 20.03 |
| Region F1                             | 6.04         | 5.33         |              |              |              |              |              |              |              |               | F1   | 11.37 |
| Region F2                             | 3.86         | 14.71        |              |              |              |              |              |              |              |               | F2   | 18.57 |
| Region F3                             | 6.88         | 10.56        |              |              |              |              |              |              |              |               | F3   | 17.44 |
| Region F4                             | 15.86        | 11.64        |              |              |              |              |              |              |              |               | F4   | 27.50 |
| Region F5                             | 11.74        | 12.78        |              |              |              |              |              |              |              |               | F5   | 24.52 |
| Region F6                             | 11.93        | 6.18         |              |              |              |              |              |              |              |               | F6   | 18.10 |
| Region F7                             | 5.96         | 9.71         |              |              |              |              |              |              |              |               | F7   | 15.68 |
| Region F8                             | 14.79        | 13.13        |              |              |              |              |              |              |              |               | F8   | 27.92 |
| Region F9                             | 15.07        | 13.70        |              |              |              |              |              |              |              |               | F9   | 28.77 |
| Region F10                            | 10.59        | 6.44         |              |              |              |              |              |              |              |               | F10  | 17.01 |
| Region G1                             | 13.85        | 6.71         |              |              |              |              |              |              |              |               | G1   | 20.56 |
| Region G2                             | 10.80        | 9.64         |              |              |              |              |              |              |              |               | G2   | 20.24 |
| Region G3                             | 14.50        | 10.24        |              |              |              |              |              |              |              |               | G3   | 24.75 |
| Region G4                             | 7.79         | 16.28        |              |              |              |              |              |              |              |               | G4   | 24.06 |
| Total                                 | 720.58       | 661.16       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Maximum                               | 22.75        | 18.36        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Minimum                               | 1.52         | 1.54         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |       |
| Average                               | 10.92        | 10.02        |              |              |              |              |              |              |              |               |      |       |
| Standard Deviation                    | 4.77         | 3.90         |              |              |              |              |              |              |              |               |      |       |
| Mode                                  | #N/A         | #N/A         |              |              |              |              |              |              |              |               |      |       |
| Median                                | 11.06        | 10.86        |              |              |              |              |              |              |              |               |      |       |
| Profitability Quotient                | 1.44         | 1.32         |              |              |              |              |              |              |              |               |      |       |
| 1381.74 Total All Simulations         |              |              |              |              |              |              |              |              |              |               |      |       |
| 22.75 Maximum All Simulations         |              |              |              |              |              |              |              |              |              |               |      |       |
| 0.00 Minimum All Simulations          |              |              |              |              |              |              |              |              |              |               |      |       |
| 10.47 Average All Simulations         |              |              |              |              |              |              |              |              |              |               |      |       |
| 0.0136 Profit Gauge                   |              |              |              |              |              |              |              |              |              |               |      |       |

Figure 61. Profitability quotient and profit gauge for low-profit scenario



| TOTAL MANDATORY PROFIT PER SIMULATION |              |              |              |              |              |              |              |              |              |               |      |        |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------|--------|
| Zone                                  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 | Simulation 7 | Simulation 8 | Simulation 9 | Simulation 10 | Zone | Total  |
| Region R                              | 105.00       | 51.43        |              |              |              |              |              |              |              |               | R    | 156.43 |
| Region A1                             | 49.00        | 70.51        |              |              |              |              |              |              |              |               | A1   | 119.51 |
| Region A2                             | 49.00        | 49.00        |              |              |              |              |              |              |              |               | A2   | 98.00  |
| Region A3                             | 86.85        | 56.08        |              |              |              |              |              |              |              |               | A3   | 122.92 |
| Region A4                             | 63.00        | 86.05        |              |              |              |              |              |              |              |               | A4   | 129.05 |
| Region A5                             | 84.00        | 49.80        |              |              |              |              |              |              |              |               | A5   | 133.80 |
| Region A6                             | 56.00        | 56.00        |              |              |              |              |              |              |              |               | A6   | 112.00 |
| Region B1                             | 28.00        | 70.00        |              |              |              |              |              |              |              |               | B1   | 98.00  |
| Region B2                             | 56.57        | 78.00        |              |              |              |              |              |              |              |               | B2   | 126.57 |
| Region B3                             | 87.47        | 68.80        |              |              |              |              |              |              |              |               | B3   | 136.16 |
| Region B4                             | 56.00        | 28.00        |              |              |              |              |              |              |              |               | B4   | 84.00  |
| Region B5                             | 49.00        | 49.00        |              |              |              |              |              |              |              |               | B5   | 98.00  |
| Region B6                             | 28.00        | 86.23        |              |              |              |              |              |              |              |               | B6   | 87.23  |
| Region B7                             | 73.46        | 54.35        |              |              |              |              |              |              |              |               | B7   | 127.81 |
| Region B8                             | 70.00        | 63.00        |              |              |              |              |              |              |              |               | B8   | 133.00 |
| Region B9                             | 49.00        | 42.00        |              |              |              |              |              |              |              |               | B9   | 91.00  |
| Region B10                            | 42.00        | 86.34        |              |              |              |              |              |              |              |               | B10  | 111.34 |
| Region B11                            | 35.00        | 80.99        |              |              |              |              |              |              |              |               | B11  | 125.99 |
| Region C1                             | 84.00        | 56.33        |              |              |              |              |              |              |              |               | C1   | 142.33 |
| Region C2                             | 88.33        | 61.31        |              |              |              |              |              |              |              |               | C2   | 147.85 |
| Region C3                             | 56.00        | 84.29        |              |              |              |              |              |              |              |               | C3   | 120.29 |
| Region C4                             | 63.00        | 55.32        |              |              |              |              |              |              |              |               | C4   | 118.32 |
| Region C5                             | 81.00        | 75.19        |              |              |              |              |              |              |              |               | C5   | 186.19 |
| Region C6                             | 67.94        | 56.11        |              |              |              |              |              |              |              |               | C6   | 124.05 |
| Region C7                             | 56.00        | 64.73        |              |              |              |              |              |              |              |               | C7   | 120.73 |
| Region C8                             | 67.88        | 83.00        |              |              |              |              |              |              |              |               | C8   | 130.88 |
| Region C9                             | 63.00        | 87.95        |              |              |              |              |              |              |              |               | C9   | 130.95 |
| Region C10                            | 63.00        | 42.00        |              |              |              |              |              |              |              |               | C10  | 105.00 |
| Region C11                            | 35.00        | 58.48        |              |              |              |              |              |              |              |               | C11  | 85.48  |
| Region D1                             | 77.00        | 77.05        |              |              |              |              |              |              |              |               | D1   | 154.05 |
| Region D2                             | 73.86        | 70.80        |              |              |              |              |              |              |              |               | D2   | 143.86 |
| Region D3                             | 56.00        | 49.00        |              |              |              |              |              |              |              |               | D3   | 105.00 |
| Region D4                             | 87.27        | 57.23        |              |              |              |              |              |              |              |               | D4   | 124.50 |
| Region D5                             | 84.00        | 55.81        |              |              |              |              |              |              |              |               | D5   | 139.81 |
| Region D6                             | 55.54        | 42.00        |              |              |              |              |              |              |              |               | D6   | 87.54  |
| Region D7                             | 83.02        | 49.00        |              |              |              |              |              |              |              |               | D7   | 132.02 |
| Region D8                             | 70.00        | 70.78        |              |              |              |              |              |              |              |               | D8   | 140.78 |
| Region D9                             | 81.75        | 42.00        |              |              |              |              |              |              |              |               | D9   | 103.75 |
| Region D10                            | 54.83        | 84.00        |              |              |              |              |              |              |              |               | D10  | 136.83 |
| Region D11                            | 70.00        | 49.00        |              |              |              |              |              |              |              |               | D11  | 119.00 |
| Region D12                            | 46.10        | 87.73        |              |              |              |              |              |              |              |               | D12  | 113.83 |
| Region E1                             | 63.00        | 131.81       |              |              |              |              |              |              |              |               | E1   | 184.81 |
| Region E2                             | 42.00        | 32.27        |              |              |              |              |              |              |              |               | E2   | 74.27  |
| Region E3                             | 53.91        | 75.85        |              |              |              |              |              |              |              |               | E3   | 128.08 |
| Region E4                             | 87.45        | 96.00        |              |              |              |              |              |              |              |               | E4   | 185.45 |
| Region E5                             | 83.00        | 71.96        |              |              |              |              |              |              |              |               | E5   | 134.96 |
| Region E6                             | 35.29        | 48.75        |              |              |              |              |              |              |              |               | E6   | 82.04  |
| Region E7                             | 91.00        | 85.51        |              |              |              |              |              |              |              |               | E7   | 166.51 |
| Region E8                             | 42.00        | 47.14        |              |              |              |              |              |              |              |               | E8   | 89.14  |
| Region E9                             | 62.97        | 77.00        |              |              |              |              |              |              |              |               | E9   | 139.97 |
| Region E10                            | 73.20        | 49.00        |              |              |              |              |              |              |              |               | E10  | 122.20 |
| Region E11                            | 56.48        | 56.00        |              |              |              |              |              |              |              |               | E11  | 112.48 |
| Region F1                             | 28.00        | 77.00        |              |              |              |              |              |              |              |               | F1   | 105.00 |
| Region F2                             | 49.00        | 86.00        |              |              |              |              |              |              |              |               | F2   | 147.00 |
| Region F3                             | 55.56        | 84.00        |              |              |              |              |              |              |              |               | F3   | 139.56 |
| Region F4                             | 50.00        | 73.03        |              |              |              |              |              |              |              |               | F4   | 129.03 |
| Region F5                             | 53.64        | 63.00        |              |              |              |              |              |              |              |               | F5   | 116.64 |
| Region F6                             | 35.00        | 70.00        |              |              |              |              |              |              |              |               | F6   | 105.00 |
| Region F7                             | 47.30        | 28.00        |              |              |              |              |              |              |              |               | F7   | 75.30  |
| Region F8                             | 79.12        | 63.00        |              |              |              |              |              |              |              |               | F8   | 142.12 |
| Region F9                             | 28.00        | 96.00        |              |              |              |              |              |              |              |               | F9   | 128.00 |
| Region F10                            | 84.00        | 49.00        |              |              |              |              |              |              |              |               | F10  | 133.00 |
| Region G1                             | 56.00        | 47.78        |              |              |              |              |              |              |              |               | G1   | 103.78 |
| Region G2                             | 71.75        | 72.06        |              |              |              |              |              |              |              |               | G2   | 143.81 |
| Region G3                             | 35.00        | 56.00        |              |              |              |              |              |              |              |               | G3   | 91.00  |
| Region G4                             | 47.58        | 42.00        |              |              |              |              |              |              |              |               | G4   | 89.58  |
| Total                                 | 3915.51      | 4166.75      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Maximum                               | 105.00       | 131.81       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Minimum                               | 28.00        | 28.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          |      |        |
| Average                               | 58.33        | 63.13        |              |              |              |              |              |              |              |               |      |        |
| Standard Deviation                    | 16.83        | 18.28        |              |              |              |              |              |              |              |               |      |        |
| Mode                                  | 56.00        | 49.00        |              |              |              |              |              |              |              |               |      |        |
| Median                                | 56.53        | 83.00        |              |              |              |              |              |              |              |               |      |        |
| Profitability Quotient                | 7.83         | 8.33         |              |              |              |              |              |              |              |               |      |        |
| 6052 26 Total All Simulations         |              |              |              |              |              |              |              |              |              |               |      |        |
| 131.81 Maximum All Simulations        |              |              |              |              |              |              |              |              |              |               |      |        |
| 0.00 Minimum All Simulations          |              |              |              |              |              |              |              |              |              |               |      |        |
| 61.23 Average All Simulations         |              |              |              |              |              |              |              |              |              |               |      |        |
| 0.0808 Profit Gauge                   |              |              |              |              |              |              |              |              |              |               |      |        |

Figure 63. Profitability quotient and profit gauge for medium-profit scenario

## CONCLUSION

The chief distinction that my dissertation has is that it shows that total revenue and total profit can be maximized by selected inclusion or exclusion of submarkets of a larger trade area. A computer application that contains various algorithms is presented that solves for which submarkets are to be included and which excluded. Characteristics of the consuming population as well as the delivery business are exogenous inputs to the simulation. Characteristics of the consuming population include population density, rate of consumption and total population per region. Characteristics of the delivery business includes required profit margin, delivery charge per region, intra-regional drive times, one-way drive times from the store, and mandatory profit (for all regions, or set by distance from the home store). The results are sensitive to the specification of the parameters of the simulation. The simulation can be calibrated to closely correspond to real world parameters and trade areas, thereby allowing delivery businesses to identify when to open and serve various submarkets of its larger trade area, and when to exclude those submarkets.

This dissertation is the first published work that includes the concept of mandatory profit by submarket. Mandatory Profit is the profit that must be projected before a submarket will be served by a home delivery service. This is an important addition to business management procedures because a main cause of online grocer failures is lack of profitability. The simulation and algorithms presented in this dissertation introduces a tool to allow home delivery services in general, and online grocers in particular, to

correctly assess as well as decrease the risk of offering their business services. The application presented in this dissertation can be used to assist business ventures in acquiring venture capital because total revenue and total profit can be calculated before the actual expense of starting business operations. After the model is calibrated with reasonable values for the parameters of the simulation, the delivery service can calculate the customer base. Actual customer addresses and their geographic coordinates can be input into the simulation. The time in which submarkets turn profitable can be calculated. The simulation can also calculate the number of delivery trucks needed, and the cycles (times per day, week, or month) that regions became profitable. Conversely, a delivery service can calculate which submarkets provide insufficient profit to include within active delivery areas. This means that the grocer can choose to defer delivery to those regions until a later time. Postponing deliver to some regions from the inception of the delivery initiative is significantly preferable than denying some customers their groceries “occasionally” because the regions in which those customers live are not profitable enough to deliver (have not met the required mandatory profit). Denying groceries to customers living in a region that has previously received groceries from the grocer can very well result in losing those customers for good.

Therefore, my dissertation, by virtue of its unique mandatory profit functionality, can allow a potential online grocer (or other similar delivery service) to better forecast the amount of delivery-related employees it must have, more accurately determine the amount of trucks it will need, possibly attain start-up capital more expeditiously, and preempt losing customers through denied orders once the delivery initiative has begun.

Therefore, my dissertation should be considered to be a trade area expansion business model and not a routing optimization application such as ESRI's Network Analyst.

Sears has made remarkable improvements in tracking assets, including appliances to be delivered; the optimization of delivery patterns; and the prediction of road volumes (Environmental Science Research Institute, 2005a). ArcView Network Analyst is used as the backbone technology for this logistical route optimization program.

Network Analyst's functionality includes route optimization, drive time analytics, shortest path algorithms, and directions for delivery drivers (Environmental Science Research Institute, 2005b). According to ESRI, dispatchers can create routes for the appliance delivery drivers in 10% of the time that it took them before the implementation of the new GIS initiative. Customer satisfaction has increased because of more timely and reliable deliveries. Also merchandise can be returned to the store more expeditiously (Environmental Science Research Institute, 2005c).

The Network Analyst-facilitated home delivery initiative is called the Enhanced Home Delivery Service (EHDS). The system automatically assigns drivers and trucks to customers and records drive times, driver stops, and delivery times. EHDS includes algorithms for solving "vehicle routing problems within time windows" (Weigel, 1999). EHDS generates reports that include the driver's name, orders delivered late, direction reports (to the customers premises), stop reports that include the homes visited and in what order, travel times including waiting times, and average stops per route (Weigel, 1999).

Although the Enhanced Home Delivery Service has sophisticated algorithms for minimizing distance traveled and maximizing customer satisfaction, the application does not allow Sears to predetermine how profitable a delivery must be in order to defray the costs of delivery such as wages, fuel charges, and depreciation on the vehicles and operational equipment. The ESRI product does not allow the user to solve for those submarkets of a larger trade area that can be profitably served. This is a differentiating factor of my application in that the mandatory profit (that which much be attained by a run to a region) is not possible to mandate with the EHDS system. There are significant factors that differ from delivering groceries as opposed to delivering big-ticket appliances. One such factor is that many large appliances easily run into hundreds, if not thousands, of dollars. Therefore, the necessity of calculating the predetermined profit for delivery of big ticket items should be less than that of figuring the profitability of bags of groceries worth tens of dollars. In other words, a refrigerator sold at \$800 may already reflect a 40 to \$100 profit. Also, the EHDS system does not allow for the input of delivery charges in the calculation of fees earned by the delivery of an appliance. But this is of course attributable to Sears offering free delivery of its appliances.

All costs are included in the base charge of the groceries to the customers. These charges include, but are not limited to wages and salaries; vehicle fuel costs; utilities for the home store (electric, gas, water); taxes incurred on income; taxes incurred upon the purchase of land, fixed machinery, structures, computers and computer software, and more; depreciation (wear and tear) of vehicles and fixed machinery; wholesale and retail cost of groceries to the grocer; insurance; repairs to machinery and vehicles; services incurred such as for outsourcing and services (legal, accounting, etc.); employee health

care subsidizing; registration costs of vehicles; start up costs including store shelves and associated structures, refrigerators, ovens, employee uniforms; advertising; and more.

After accounting for all of these initial and ongoing costs, a percent profit is derived. This should be considered similar to the way a brick and mortar grocer calculates the percent profit (except a brick and click grocer would have the additional cost of delivery trucks and delivery driver wages, whereas a pure online grocer would not have initial costs of cash registers and in-store advertising or sales personnel). For example, after the store calculates all of the above costs and finds that for every dollar of groceries sold 98.5 cents are costs, the profit margin is 1.5%. If the grocer decides that a delivery charge should be added to this, the grocer can then choose to employ the delivery charge function in my application to see when and how often the regions simulated will reach the mandatory profit. The grocer can then choose to run similar simulations with a zero delivery charge. After both of these simulation sequences are run, the grocer could then juxtapose the results of the self-generated reports to see which business model (that which uses delivery charges, or that which uses a zero delivery charge) is more feasible considering both customer satisfaction and overall profitability. It is also possible to enter smaller and larger amounts of delivery charges to ascertain a customer satisfaction (in terms of timely grocery delivery)/overall profit dichotomy.

This is not to say that this profit-related business model is the only way to incorporate cost / profit into the overall model. Another possible way would be to include all operational expenses into the grocery charge, then compensate for the costs incurred by delivering groceries by adding on a delivery charge to some or all orders placed. Because my application allows for delivery charges to be added on to orders by a

regional basis, and since orders sent to more distant regions are more costly, the grocer can compensate for the graduated delivery costs (less for closer regions, more for further regions) by applying a higher delivery charge to customers who live farther away from the store, thereby creating a correlation between delivery costs and delivery charges.

To make my logistic application more attractive to grocers I would add the following functionality to the application

- Metamorphic zones
- Handoff point algorithms
- Better database connectivity (to run queries)
- A user interface that allows point and click set up of the hexagons to conform to the trade area of the grocery store
- Overlay the hexagons in item 4 above onto a air photo or satellite image

Delivery regions should not be stagnant or immutable polygons. Instead delivery zones should be “metamorphic” entities. Metamorphic delivery zones should encompass the most profitable addresses that require delivery to at any particular instant. Besides profit maximization functionality, metamorphic real-time delivery zones should minimize delivery cost and delivery times.

To elucidate, if a single region has met its mandatory profit (say region X), and regions geographically adjacent to that region (regions Y and Z) have not yet met their mandatory profit (provided those regions have at least one outstanding undelivered order), the system would automatically connect regions X,Y, and Z together and inform the dispatcher to send a single truck to the three regions.

Factors to include in this decision are whether, historically, regions Y and Z have not met their mandatory profit in a cyclical manner that is chronologically near to the

dispatch of the truck to region X. If past customer behavior shows, beyond a reasonable statistical doubt, that regions Y and Z will meet mandatory profit shortly, it might be preferable to have the truck make a run to only region Z, return to the store quickly, and load up again with the full amount of orders for regions Y and Z, which by that time will have met their mandatory profit, and would result in higher earnings for the grocer.

Metamorphic regions do not have to be adjacent. Relatively distant, but as yet non-profitable regions could be combined by joining regions between the two regions to create a “corridor of profitability.”

Even though my application has the potential to greatly decrease the risk of not making a profit on a delivery dispatch, the *maximization* of the profit potential of a particular run, along with the problem of reaching each and every customer has not been adequately addressed yet. One reason that profit earning potential is not maximized in my application is that regions are rigidly defined geographic areas. What will happen using only rigid delivery regions is that a specific delivery truck might deliver to all the customers within a zone, then either go to the next zone that has outstanding orders or return to the home store. Although the route traversed on the way to the zones and the route traveled within the zones can be minimized by common GIS routing functions, no consideration is given to the optimization possibilities that could exist by combining or breaking up the zones.

It could be the case that zone #23 and zone # 24 are adjacent. Both zones have surpassed their profitability thresholds. But on this particular delivery dispatch, 70% of the customers in zone 24 are located in the eastern part of the zone. In this case, by not adhering to strict hexagonal areas, optimization possibilities exist. If the total amount of

deliveries to zones 23 and 24 exceed the capacity that one truck can carry, the simplest strategy might be to first deliver to one of the zones, come back to the store, restock the truck, and deliver to the other zone. After all, both zones reached mandatory profit.

However, if the truck has enough capacity to deliver to all of the eastern part of zone 24 (which contains 70% of the orders for that zone) plus enough capacity to deliver to all of zone 23, the profit for that specific delivery could be 70% greater than if it delivered to region 24, returned home, then went to region 23.

What about the remaining 20% of the customers in the western part of zone 24 that haven't received their groceries yet? There has to be some probability that those customers can be grouped with another zone that lies somewhere to the west of zone 24. If so, those remaining customers could be serviced with a truck that goes to that western area.

Of course, this type of dynamic routing is not as easy as it seems. What if the customers in the western part of zone 24 were promised their groceries at the same time as those in the eastern part? They would be very unhappy if they had to wait for the next truck. This means that rigidly defined zones are not the most efficient geographic areas to deliver to. The key is to have a logistical application with the capability to morph delivery zones to whatever shape is necessary at a particular time while taking into consideration numerous variables. Possible shapes could be elongated, finger shaped areas, or even archipelago-shaped areas. Delivery archipelagos may very well be the most common type of delivery delineation because of their profitability potential. Each "island" in the archipelago might just be a small fraction of a region (maybe one or two blocks). The application should dynamically generate and delineate optimal "island

hopping” delivery dispatches instead of just showing blocks of zones that have met mandatory profit. Succinctly stated, it may be much more efficient and profitable to deliver to elongated or archipelago shaped zones instead of rigid hexagonal zones.

One important reason for this postulation is that instead of waiting for zones of a predetermined shape to reach the profitability threshold, the online grocer can be delivering to irregular shaped zones continually because the probability of an indeterminately shaped region reaching mandatory profit can be significantly greater than a predetermined region reaching that same threshold, even if both the indeterminately shaped region and predetermined region are of the same area (as measured in square miles, for example). The only caveat to this rule is that any indeterminate region be allowed to assume the exact shape and location as any predetermined region in the universal region.

Also, because more customers would be delivered to using metamorphic zones, customer satisfaction will increase. Moreover, customers who are denied orders may be lost for good. Metamorphic regions can have the potential to “grab” these otherwise unserved customers and include them in the overall profitability plan.

My application allows for the grocery store to evaluate which regions to “open” and serve, and which not. Once a decision is made to serve, they must serve regardless of the profit. So a merchant can use my application to assist in making a decision of when to open regions.

Various conclusions can be derived from the concept of attempting to keep the profit level, as high as possible on a delivery. The first conclusion is that the metamorphic

delivery zones will change often, if not constantly, as new orders come in and old orders are delivered.

A second conclusion is that by using archipelago-shaped zones, the profit level can become much higher than the usage of predetermined zones. This is accomplished by including orders from regions that might not have met the mandatory profit if the regions were stagnant shaped hexagons. The point being made here is that by allowing the logistic application to dynamically create polymorphous regions, the profit per delivered route can increase along with the amount of customers delivered to.

The inclusion of handoff points, or the locations of where trucks in the field receive groceries from other trucks in the field, is important. The attainment of this functionality would necessitate the inclusion of shortest-distance networking algorithms, and forecasting functionality. The forecasting functionality would determine historically what addresses ordered what groceries in the past, and when they did so. Larger trucks in the field could be pre-loaded with these goods and meet with other trucks so they do not have to return to the store. This is a very important function that should be incorporated.

The application that I developed is based on using Excel™ spreadsheets as the back-end database. The application would be much more powerful if the data was in an Access, DB2, or Oracle database. This is because sophisticated queries could be run to answer questions such as what regions become profitable when, what customers have waited the longest to receive their groceries, and what trucks are most efficient in traversing the network. Therefore, this is the third aspect I will improve on when I acquire more programmers.

My application consists of a predetermined arrangement of hexagonal regions. This shape will have to be altered to create an appropriate overlay on a real town, or section of a town. Therefore, the ability to drop and drag the hexagons to whatever shape is necessary is an important improvement that must be made. The regions should also be able to be manipulated over air photos and satellite images so the underlying topography, streets, and buildings could be better shown under the regions.

The reason I programmed it using VBA in Excel™ is that Excel™ is practically a ubiquitous application. A preponderance of companies are familiar with the application which could result in a shorter learning curve for companies that want to programmatically change the application. Excel™ is also equipped with spreadsheets that can easily be used for a back-end database.

Visual Basic for Applications, despite having its limitations, is still a quite powerful programming language. For reasons of demonstrating the potential utilization of my logistic application, the Excel™ / VBA combination was sufficient. It is recognized, however, that other languages, such as Visual Basic, C++, or Java would be preferable, because the simulations would run faster. However, a main purpose of mine was not to have the application run fast, but instead have it run slower so those viewing it could better see the trucks being dispatched, the regions changing color in concordance with the number of orders generated, and the regions meeting their respective mandatory profit. For these purposes a slower running application has its benefits.

The main weaknesses of my model is that it does not contain the functionality for metamorphic regions, handoff points, and better database connectivity. It also is not

optimized for speed, which should be changed by re-programming it in a higher-level programming language.

The main contribution that my dissertation has contributed to academic knowledge is my application automates trade areas. Thrall (2002b) wrote about trade area expansion and drew upon the actual geographic expansion of Red Lobster out of central Florida. Thrall discussed the costs and benefits of a multi-branch retailer choosing various expansion strategies, including hierarchical dispersed versus spatially contiguous regional saturation. However, Thrall's discussion while seminal did not provide an operational algorithm or procedure that allowed the decision maker to calculate the differences in profit between alternative geographic expansion scenarios. My dissertation fills this gap in the literature by taking trade area analysis the next logical step.

My dissertation contributes to the academic body of knowledge by answering questions like, "what markets and submarkets should be included to insure profitability by delivering groceries?" and "what values do you need in combination to reach a predetermined profit?" These questions have not been adequately answered either in academic literature or in industry.

Because profitability is naturally the goal of any grocer, this application gives an indication to the grocer about what clusters or sets of attributes will work to achieve the required level of profit. Each simulation that is run can portray a different scenario of what is needed to achieve profitability. These facets are lacking in the realm of current academic knowledge.

The best way to optimize the profit ascertaining potential of my application would be to incorporate the metamorphic zone functionality stated above. Aside from that, goal-

seeking functionality would have to be added. To do this, regions would have to be specified and the mandatory profit would be calculated by the amount of profit a truck earns on a run to more than one region. For example, a truck is dispatched with an extra amount of groceries. While the truck is in the field, its route changes according to the location of the customers who are constantly placing orders. In this scenario, the trucks are the dependant variables, and the customers are the independent variables.

A grocer who delivers would certainly hope for inelastic demand as it pertains to delivery charges. This is because if the amount of groceries ordered will decrease at a decreasing rate in proportion to the increase of delivery charge. In this scenario the grocer could be relatively assured that a small increase in delivery charge would result in a smaller monetary decrease in groceries ordered.

Because food is a non-discretionary item, meaning that people have to eat, food has a propensity to have an inelastic demand associated with it. However, the choice to have the food delivered is discretionary, giving some impetus to elastic demand with regards to home delivery of groceries.

Therefore, grocers should strive to keep the delivery charge as minimal as possible, or attempt to offset the delivery charge with excellent service. Another point that could serve to offset the elasticity of demand when it comes to delivery service that it does cost customers money, in fuel, wear and tear on their vehicles, and time to shop. If the cost of delivery does not supersede these three cost points then the elasticity of demand in regards to deliveries could be effectively nullified.

Although I said much about my logistical application being a simulation, it is really more than that. After a grocer uses my application to intelligently decide whether to

begin delivering groceries or not, he or she can use the application as an operational front end to actually dispatch the trucks to the regions.

Of significant importance is the value this application can have to the failure-prone grocery delivery business. With judicious usage of this application, grocers who might otherwise fail to adequately make a profit can predetermine the plausibility of success before capital is invested in delivery operations. Therefore, the application that I developed is not merely a concept, but a unique working application that has yet to be introduced into the decision-making realm of prospective, and already operational e-grocers.

In other words, the Main Map interface can be used as a logistical dashboard where orders that come in are automatically input into the database, causing the logistical dashboard to notify the dispatcher to send a truck to the regions that have met their predetermined profitability levels. This will of course require connecting the application to a back end web interface.

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## BIOGRAPHICAL SKETCH

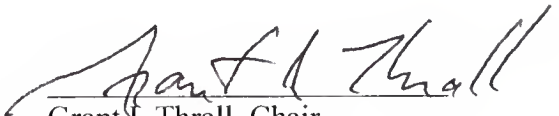
After attaining his Bachelor of Science degree in journalism at the University of Florida in 1990, and working as a journalist for a few years, Keith Herrel decided that his writing skills would be best utilized in the field of business geography.

Therefore he attained a Master of Arts degree in decision and information sciences before attaining his Master of Science Degree in Geography. Both of these degrees are from the University of Florida.

Then, while working as a geographic information systems programmer analyst, he completed the Master of Business Administration course at Florida State University.

After completing his doctoral degree in Geography, he plans to use his knowledge to further research the exciting field of geography's relevance to logistically delivering goods via the internet.

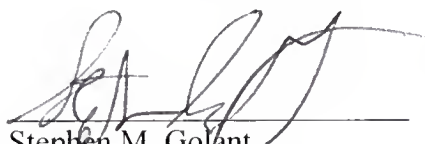
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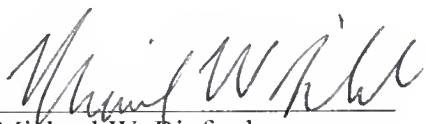
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Stephen M. Golant  
Professor of Geography

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May 2006

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